EXHIBIT 29

MATSON & ASSOCIATES

Expert Report

Monsanto's Manufacture, Promotion and Sale of Polychlorinated Biphenyls (PCBs)

City of Spokane, v. Monsanto Company, et al.
CASE NO. 15-CV-00201-SMJ

Prepared for:
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I. Qualifications

I am Emeritus Professor of Environmental Engineering at the Pennsylvania State University and the founder of Matson & Associates, Inc. My academic background includes a B.S. and M.S. in Chemical Engineering from the University of Toledo and a Ph.D. in Environmental Engineering from Rice University. My relevant experience includes working as a process chemical engineer in an oil refinery and as a process/environmental engineer at a chemical plant which manufactured polymers, and as an environmental engineering consultant to the chemical industry. I taught courses at the University level in topics such as environmental engineering, environmental chemistry, engineering design and hazardous waste management. I conducted and supervised research in areas including environmental chemistry, chemical engineering, and chemical emissions and releases from manufacturing facilities. I published papers in peer reviewed journals and worked with environmental regulatory agencies on permitting issues. From 1991 to 1993, I served on the Texas Air Control Board as Chair of the Enforcement Committee in which corporate historical ethical responsibilities were significant in determining fines and other regulatory actions; and from 1992 to 1993 as Chair of the Regulations Development Committee involving the formulation of State Regulations to conform with the Federal 1990 Clean Air Act revisions.

With respect to product safety, in the 1980s and 1990s, I co-invented and patented in partnership with the Monsanto Corporation, Towerbrom, a commercial cooling tower water treatment chemical which contained a chlorinated hydrocarbon in the compound. My roles in the project included evaluation of its safe application and use, which was delineated in its Material Safety Data Sheet.

My expertise on corporate responsibility issues, besides working as an employee for two major companies, Sun Oil and Exxon, was demonstrated by applying ethical considerations to case studies in the engineering courses I taught to undergraduates. Also, as an environmental engineering consultant to industry on matters of chemical contamination and treatment, I assisted clients on permit applications and revisions including ethical considerations.

I have been qualified to testify at trial in Federal and State Courts in a number of cases involving the releases of polychlorinated biphenyls (PCBs) into the environment. My CV and four-year case history are attached in Appendix A.

II. Basis of Opinions

I have formed my expert opinions based upon [a] documents supplied through discovery, [b] publicly available information, and [c] my education, training and experience, to a reasonable degree of engineering certainty.[1] I reserve the right to supplement or modify my opinions as additional information becomes available and is provided to me.

[1] Appendix E contains a list of documents from discovery.

III. Compensation

My hourly rate for preparing this expert report is $450. My hourly rate for testimony is $900.

IV. Methodology

I was retained by Baron & Budd, PC and Kelley Drye & Warren, LLP to evaluate Monsanto's role, conduct, and duties as a corporate citizen with respect to its manufacture, promotion and sale of polychlorinated biphenyls (PCBs) as well to evaluate Monsanto's actions after the widespread presence of PCBs in the environment was identified and confirmed by the scientific community. To formulate my expert opinions, I reviewed contemporaneous industry standards and Monsanto's corporate policies with respect to social responsibility to protect the public and the environment from the actions and products of corporations. I analyzed Monsanto's internal and promotional PCB and Aroclor documents and its communications with customers, the public, the government and others about PCBs to gather information on exposures to PCBs under various environmental conditions, the evolution of scientific and technical knowledge of environmental impacts from PCBs, how Monsanto communicated information to its customers and users of its PCB-containing products, and to the public, government and others, and what actions were taken by Monsanto to protect the public and the environment from exposure to PCBs and PCB-containing materials. I also reviewed technical literature on the physical and chemical properties of PCBs related to their impact on the environment. This literature included publicly available reference materials authored by Monsanto employees on a variety of relevant topics. The Monsanto authored publications that I relied upon are specifically notated in the "Literature References" section (Section XIII).

V. Opinions

- Monsanto was the sole U.S. producer of PCBs, which were toxic, volatile, persistent and bioaccumulative in the environment. Based on the scientific and technical information available to Monsanto during its production, marketing and sale of PCBs, Monsanto must have known that the widespread use of PCBs for applications that interfaced with the environment and widespread use of PCB-containing industrial fluids would result in pervasive and lasting environmental contamination.
- Monsanto did not act in accordance with corporate social responsibility standards and its own policies to protect the public and the environment by manufacturing, promoting and selling significant amounts of PCBs and PCB-containing fluids for open and semi-closed uses, respectively, and when made aware of the widespread PCB contamination did not take reasonable actions to mitigate the problem.

VI. Executive Summary

PCBs are classified as "persistent bioaccumulative and toxic" (PBT) and as "persistent organic pollutants" (POPs). Both classifications represent chemicals that are toxic and "adversely affect

human health and the environment around the world." (EPA, 2017).[2] The relationship between toxicity, mobility, persistence and bioaccumulation as shown in Figure 1 below results in PCBs causing a lasting environmental contamination problem. PCBs are ubiquitous in the environment; they are present in air, soil, fresh water and marine ecosystems, wildlife and humans. Their ubiquity stems from the unique relationship between their characteristics combined with the significantly large amounts of PCBs produced and sold for a wide variety of applications. An estimated 1.4 billion pounds of PCBs were manufactured by Monsanto in the U.S since 1930 (US EPA, 1976; Erickson et al, 2010).[3]

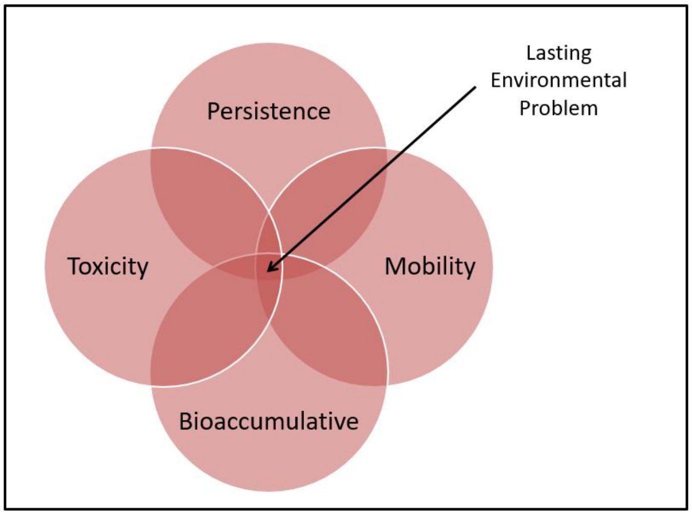

Figure 1. Relationship between important characteristics of PCBs.

The widespread use of PCBs in a variety of applications, as well as the inevitable subsequent release of PCBs and PCB-containing products created a lasting environmental contamination problem. Monsanto referred to the plasticizer applications, like coatings and sealants, as uses that could not be controlled, and classified these applications as "open uses" because the products containing PCBs were open to the environment (*i.e.* air and water)[4]. The PCBs continued to escape from these open use products over their lifetimes of use, and were transported via stormwater and atmospheric

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[2] In present day for regulatory purposes, regulators define persistence based on half-life. The criteria set by regulatory frameworks and global agreements for the most part are aligned. For example, in 1999, the EPA selected a 60 day (d) half-life for PBTs in water, soil and sediment "because contamination by chemicals with half-lives of 60 d or less can be significantly reduced within one year through natural processes and one year is a reasonable timescale to evaluate and adjust measures for controlling releases of a chemical." EPA also stated that chemicals with half-lives greater than 180 days in the same media were to be phased out. The European Commission (EC) established half-life criteria for very persistent chemicals in fresh water and sediment as 40 days and 120 days, and marine water and sediment as 60 days and 180 days (Matthies et al, 2016).

[3] U.S. imports of PCBs were approximately 0.2% of U.S. production, and approximately 150 million pounds of PCBs produced by Monsanto were exported (Erickson et al, 2010).

[4] Plasticizers are chemicals added to polymers such as rubbers and resins (e.g. plastics) to impart flexibility, workability or stretchability (Merriam-Webster, 2016). The simplest definition of a polymer is a chemical made of many repeating units, which can be formed into a wide variety of products at various thicknesses. For this report, the term "plasticizers" will also represent modifiers and extenders, two other uses for PCBs in open use applications.

deposition into the natural environment and remain there today. Certain uses of PCBs, such as extenders in pesticides, resulted in the dissemination of PCB-containing materials directly into the environment. Other uses of PCBs, such as in hydraulic equipment and heat transfer systems were classified by Monsanto has "semi-closed" and also have led to the release of PCBs into the surrounding environment during normal and expected operations, as well as during maintenance. These industrial fluids reached surface water by direct discharges or via stormwater and atmospheric transport where the PCBs accumulated and remain today. Releases of PCBs to the environment also occurred during manufacture of PCBs and disposal of PCBs and PCB containing products and fluids.

An analysis of Monsanto's role, conduct, and duties as a corporate citizen during its manufacture, promotion and sale of PCBs, which were being (and would continue to be) exposed to and released into the environment, and after widespread presence of PCBs in the environment was publicly identified and confirmed by scientific community is presented below. The responsibility of corporations to the public and the environment has long appeared in historical texts, documents, and corporate policy statements. Professional organizations, several industry representatives and other professionals described the social responsibility obligations of corporations, and recommended that social responsibility be a deep stated belief from management and part of the overall corporate strategy. Monsanto had authored similar policy statements defining its responsibilities to the public and the environment as discussed in Section IX.B. of this report. Monsanto's corporative representatives and other staff stated that Monsanto's policy statements applied to the entire time that Monsanto had manufactured and sold PCBs, which started in the early to mid-1930s.

Monsanto's manufacture, promotion, and sales of PCBs that led to the release, persistence and bioaccumulation of toxic PCBs in the environment was not in accordance with corporate social responsibility standards concerning the protection of the public and the environment from harmful products.

- Monsanto developed a comprehensive knowledge base on the ***toxicity*** of PCBs, which it obtained through publications on workers exposed to PCBs, and laboratory experiments simulating workplace conditions by testing the effects of PCB exposure to certain animals. The experiments starting in the 1930s indicated that PCB exposure caused systemic toxic effects.

- Monsanto had scientific information demonstrating that PCBs were ***mobile*** and would migrate (volatilize or leach) out of open use products upon initial use and continue to escape from those products while in use. Monsanto's own research on the migration of PCBs from open use products dated back to the early 1930s.

- Beginning in the 1930s and continuing into 1970, Monsanto created and sustained the PCB plasticizer market by promoting and selling PCBs for many household and commercial products. Monsanto must have known PCBs would migrate out of these products causing exposures to the public and the environment. For example, Monsanto promoted PCBs as plasticizers for use in

paper draperies, floor finishes, shoe polish, paints, wood finishes, coatings for swimming pools and water towers, sealants for concrete surfaces, building caulk, carbonless copy paper, adhesives, pesticides, and insecticides. These applications and other open uses directly interfaced with and resulted in contamination of the environment.

- Monsanto disseminated misleading ***toxicity*** information via product literature and customer communications only in the context of worker exposure to PCBs at elevated temperatures that harm only occurred to workers at elevated temperatures in an industrial setting, without specifically noting that PCBs were a systemic toxin at both low exposure levels and at ambient temperatures.

- Monsanto provided its own data on ***volatilization*** (in terms of vapor pressure) in its product literature and customer communications, but the data was limited to elevated temperatures. This information was misleading because the omission of low temperature volatilization data did not allow for customers to evaluate harmful impacts to the public or the environment from open use products.

- Monsanto disseminated information in product literature specifically stating PCBs were ***not soluble*** in water. This implied that PCBs would not migrate into water in contact with the open use applications, such as PCB-containing coatings applied to the inside of concrete potable water towers or sealants applied to concrete structures utilized in marine environments.

- Monsanto promoted PCBs for many products because their characteristics imparted stability and fire-resistance in a wide range of applications and conditions. Based on the chemical structure of PCBs, Monsanto had information that PCBs were persistent such that they would not naturally or readily break down in the environment, and Monsanto promoted the value of their resistant properties in the environment. Also, Monsanto internally discussed PCB ***persistence*** in the sediments and ***bioaccumulation*** in aquatic life in waters downstream from both its PCB manufacturing plants (Alabama and Missouri), and its Pensacola facility that used a PCB-containing fluid and discharged it with wastewater into the Escambia River.

- From the early 1940s to the early 1970s, Monsanto created and sustained the PCB-containing industrial fluids market by promoting and selling industrial fluids including hydraulic fluids and heat transfer fluids for semi-closed applications. The applications were prone to leaks, spills and other releases, which permitted PCBs to escape into the environment. For example, a primary reason for Monsanto's widespread promotion and sales of PCB-containing hydraulic fluids for die casting machines was the fact that PCBs would not cause a fire or explosion when a hose ruptured and hydraulic fluid sprayed or leaked inside the factory. For decades, Monsanto had information that PCBs were being released from these systems.

- Although Monsanto highlighted the stability and fire resistance properties of PCB-containing industrial fluids in its product literature and other marketing materials, it did not disseminate information on handling of spilled, leaked or waste fluids to prevent entry into the environment,

or on the impact to the aquatic environment (***persistence*** / ***bioaccumulation***) if the fluids reached surface water via direct or indirect discharges. Omitting such information was misleading because it implied PCB-containing fluids upon reaching aquatic environments and would not cause lasting harm to aquatic ecosystems.

- For decades, Monsanto disseminated information on PCB stability in its product literature and other promotional materials, but only in the context of product performance with no mention of PCBs as a persistent contaminant in the environment.

- Monsanto purposely sold millions of pounds of PCBs for a wide variety of applications in which the escape and release of significant quantities of PCBs would and did contaminate the environment.

Monsanto's actions after the widespread presence of PCBs in the environment was publicly identified and confirmed by the scientific community were not in accordance with corporate social responsibility standards concerning the protection of the public and the environment.

- Monsanto continued to sell PCBs as plasticizers for open use applications until August 1970, and then continued to sell PCBs for carbonless copy paper (a widely used open use application) until mid-1971. Even after announcing it would cease sales of PCBs for open uses due to environmental problems, Monsanto allowed its customers to stockpile PCB reserves, permitting these continued uses. Despite the harmful effects associated with PCBs, Monsanto sold more PCBs for open uses in 1970 than any other year, despite only selling PCBs for eight months. Monsanto *continued to increase* its PCB sales *after* the widespread environmental presence of PCBs had been confirmed by scientists.

- After Monsanto discontinued sales of PCBs for open uses, it continued to market and sell "alternatives" to PCBs, such as Aroclor 5460, for use as plasticizers despite the fact that these products contained PCBs.

- Monsanto sold PCB-containing hydraulic fluids and heat transfer fluids for semi-closed applications through 1971 despite having information that PCB fluids were escaping these systems and causing contamination.

- Monsanto disseminated limited information to its customers about the PCB environmental problem in order to minimize customer concerns and protect its continued sales of PCBs.

- Monsanto did not timely share information about its customers and sales of PCBs and PCB-containing products, and provided misleading information about the use of its PCB products. By minimizing open communications with regulators, scientists, the media or the public, Monsanto hindered efforts to assess the sources and extent of PCB contamination. The ongoing discoveries of PCB sources and legacy PCB contamination demonstrate that Monsanto's actions have led to lengthy delays to address legacy PCBs in use and in the environment, particularly in stormwater, surface water, waterways, and sediments today.

VII. Polychlorinated Biphenyls (PCBs) and Aroclors: Properties, Manufacture, Use, Sales, Toxicity and Environmental Contamination

A. Physical and chemical properties and manufacturing of PCBs

PCBs also referred to as "chloro biphenyls," "chloro diphenyls," and "chlorinated diphenyls," are a class of synthetic organic chlorinated compounds. The basic chemical structure of PCBs is two bonded benzene rings (the biphenyl) with chlorine atoms, ranging from 1 to 10 attached, as shown below in Figure 2.

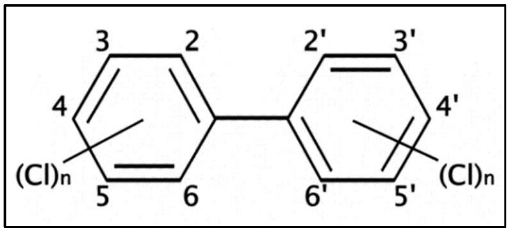

Figure 2. Generic structure of a PCB molecule showing the placement of 1 to 10 chlorines.

The varying combinations of the number and location of chlorine atoms attached to the benzene rings theoretically allows the formation of 209 different PCB compounds, commonly referred to as congeners. The 209 congeners grouped by the number of chlorines attached to the biphenyl are referred to as homologs. For example, the "penta" homolog has 42 PCB congeners containing five chlorines of which two are shown below in Figure 3.

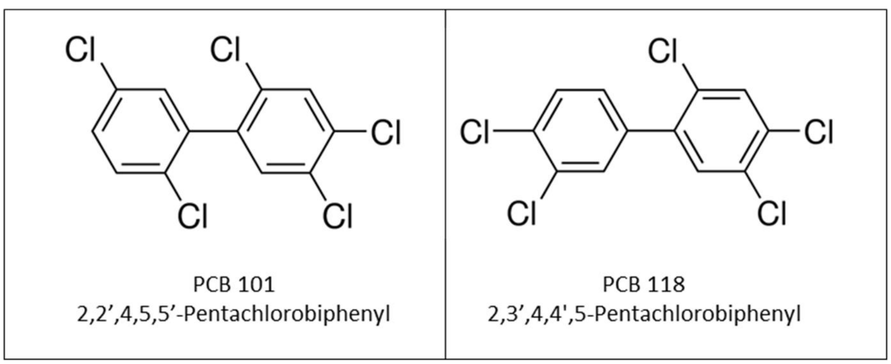

Figure 3. Chemical structure of two different PCB congeners containing 5 chlorines.

Swann Research Inc. (Swann) began producing PCBs in the United States in 1929. When Monsanto purchased Swann and its Anniston, Alabama plant in the early 1930s it became the sole producer of PCBs in the United States and remained as such until it ceased production of PCBs in 1977 (STLCOPCB4055951, 5/16/1935). In the mid-1930s, Monsanto began producing PCBs at a second site, known as the Krummrich plant, located in Sauget, Illinois (MONS 045979, 4/1955). For a limited time (1971 and 1972), Monsanto also produced PCB-containing hydraulic fluids at its St.

Louis, Missouri facility (DSW 011945, 12/11/1975). Monsanto stopped all PCB production in Anniston before November 1971, and in Sauget in 1977 (MONS 045449, 11/12/1971).

Monsanto manufactured and sold PCBs as mixtures of congeners with different degrees of chlorination. The manufacturing process began with the formation of the biphenyl, which was produced by heating benzene to over 800°C in a closed reactor in the absence of air. The reaction gases were then transferred to a series of columns and cooled to separate out the purified biphenyl (DSW 001279, 6/1935). To manufacture PCBs, biphenyls were pumped into a chlorinator in which chlorine gas was bubbled up the cylindrical column. The reaction, in the presence of a catalyst, continued until the correct density (an indicator of chlorine content) was reached, and then the crude chlorinated mixture was distilled to a finished product. The final PCB product resulted in mixtures of chlorinated biphenyls with an overall composition defined by the percent of chlorine. For example, Figure 4, below, shows a PCB compound with 54% chlorine content as a mixture of several PCB homologs[5]. As shown in the figure, the most abundant homolog in this particular mixture is the penta-chlorinated biphenyl, or five chlorine atoms attached to the biphenyl molecule. PCB mixtures with a lower percentage of chlorine will have more of the lower chlorinated congeners; and the converse is true for the mixtures with a higher percentage of chlorine (DSW 001279, 6/1935).

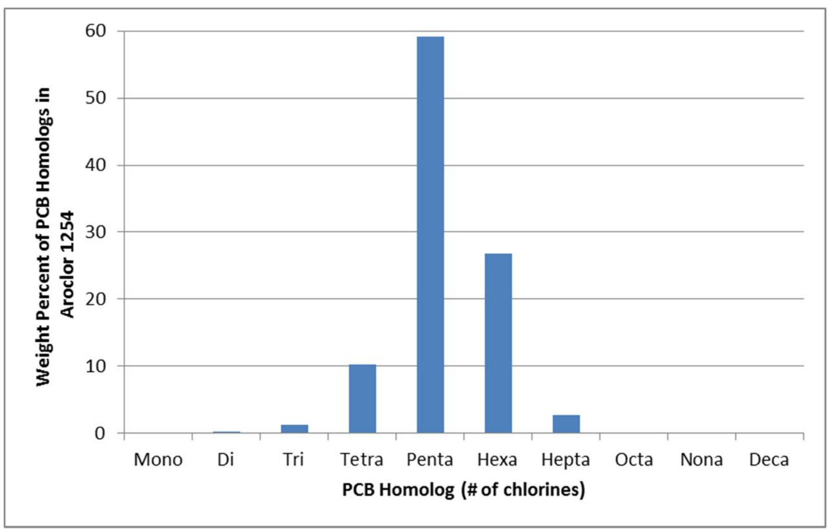

Figure 4. Typical Aroclor 1254 composition by homologue.

PCB's are characterized as semi-volatile substances with high viscosity, low solubility in water, high solubility in most organic solvents, low flammability, and having good dielectric properties. The chemical and physical properties vary depending on the congener makeup and degree of chlorination. PCB mixtures with 54% chlorine or less are oily liquids and PCB mixtures with 60% chlorine and above are resins or waxes. The different PCB mixtures imparted different properties when in use on their own or combined with other materials into final products. PCBs entered the

[5] Based on Table 4-4 in ATSDR, 2000.

environment through both use and disposal. Due to its chemical and physical properties, PCBs do not readily degrade in the natural environment. They are extremely resistant to oxidation, reduction, and substitution. They can enter the human body through exposure by inhalation, ingestion, and the skin. Also, PCBs can enter the ecological food chain and bio-magnify to elevated levels in food for human consumption.

Monsanto marketed PCB mixtures under the trade name "Aroclor", followed by a four-digit number. The first number denoted the raw material, the second number indicated whether it was distilled, and the last two digits identified the percentage of chlorine (DSW 001279, 6/1935).

Using Aroclor 1254 as an example:

- 1 = raw material was 100% biphenyl
- 2 = distilled
- 54 = 54% chlorine by mass

The Aroclor 1200 series signified products that contained only mixtures of PCBs. Monsanto made polychlorinated terphenyls (PCTs) that were comprised of three benzene rings joined together with chlorine atoms attached to the benzenes. PCTs were labeled as the Aroclor 5400 series and blends of PCBs and PCTs were known as the Aroclor 2500 and the Aroclor 4400 series[6].

B. Uses and sales of the Aroclor 1200 series

It has been estimated that over 1.4 billion pounds of PCBs were manufactured by Monsanto in the U.S since 1930 (Federal Register, 1976; US EPA 1976; deVoogt et al, 1989; Erickson et al, 2010). In 1966, Monsanto's sales of Aroclors accounted for about 75% of the world Aroclor market (PCB-ARCH0126088, 3/10/1966; PCB-ARCH0293726, 9/29/1966). Incomplete data on production and sales of the Aroclor 1200 series have been provided in Monsanto documents and are listed below in Table 1 (MONS 045979, 4/1955; DSW 532590). As shown in Table 1, Monsanto produced approximately 53 million pounds of the Aroclor 1200 series at its Sauget plant between 1936 and 1945, and sold over 860 million pounds of the Aroclor 1200 series (Anniston and Sauget) between 1957 and 1977 (DSW532590)[7]. The remaining undocumented amount (approx. 485 million pounds) was most likely produced at Anniston between 1930 and 1957, and at Sauget between 1946 and 1957.[8] Also, as shown in the notes below Table 1, some sales were not fully accounted for (plasticizers sales in 1957 and heat transfer fluids sales from 1957 – 1961).

[6] Aroclor 5460 was a distilled PCT that was chlorinated to 60% chlorine. Aroclor 2565 was comprised of 75% biphenyl and 25% PCT that was chlorinated to 65%. Aroclor 4465, made from 50% Aroclor 1262 and 50% Aroclor 5460, had an overall chlorine content of 65% (DSW 001279, 6/1935; TOWOLDMON0024978, 10/31/1966; FUN008513, 12/1975).

[7] Monsanto also produced Aroclor 1272, which was primarily comprised of decachlorobiphenyl (10 chlorines on the biphenyl). No sales records were provided for the years prior to 1957 for Aroclors 1221 through Aroclor 1272.

[8] Monsanto listed total sales of its PCBs, PCTs and biphenyls for the years 1940 -1950 (155,094,939 pounds), but did not provide sufficient information to extract the amount of the Aroclor 1200 series (PCB-ARCH0564301, 12/5/1952).

Table 1. Monsanto's Production and Sales (pounds) of the Aroclor 1200 series.

Monsanto Product	Sauget Production (1936- 1945)	Domestic Sales (1957 - 1977) [(a)]
Aroclor 1221[(b)]		7,426,000
Aroclor 1232		2,037,000
Aroclor 1242	341,434	446,928,000
Aroclor 1248	649,590	58,400,000
Aroclor 1254	18,480,050	135,821,000
Aroclor 1260	28,656,021	91,657,000
Aroclor 1262[(b)]	2,277,302	7,175,000
Aroclor 1268	166,387	2,882,000
Aroclor 1016 [(c)]		111,181,000
Aroclor 1269	926,528	N/A
Aroclor 1270	1,283,905	N/A
Aroclor 1271	5,800	N/A
Total	**52,787,017**	**863,507,000**

(a) Records did not include plasticizer sales in 1957 or heat transfer sales for 1957 - 1961
(b) Aroclor 1221 & 1262 continued to be sold in blends for plasticizers post 1970 (FUN008508, 12/1975)
(c) Aroclor 1016 sold for capacitors, 1971 – 1977. It was a 41% chlorinated biphenyl.

Table 2. Monsanto's Domestic Sales of the Aroclor 1200 Series by Application.

Applications	Sales (pounds) (1957 - 1977)
Capacitor	416,826,000
Heat Transfer[(a)]	20,282,000
Hydraulics / Lubricants	60,989,000
Misc. Industrial[(b)]	21,792,000
Petroleum Additives [(c)]	1,439,000
Plasticizer Applications [(d)]	144,494,000
Transformer	197,687,000
Total	863,509,000

(a) Monsanto did not report sales for heat transfer until it started using the tradename "Therminol" in 1962.[9]
(b) Includes Santovac 1 & 2 and Turbinol 153[10]
(c) Monsanto sold Aroclors for this application only in 1969.
(d) Records did not include sales in 1957.

[9] Monsanto began selling Aroclors for heat transfer systems in the 1940s but did not introduce the tradename "Therminol" until 1962 (Monsanto Chemical Co, 1947; McArdle et al, 1948; C & E News, 1962).

[10] HARTOLDMONOO25543@ 0025666, 11/16/1971

Monsanto sold the Aroclor 1200 series for many different applications as shown in Table 2, above (DSW 532590, no date). As shown in Figure 5 below, Monsanto's total sales of the Aroclor 1200 series steadily increased after 1958 with a pronounced rise between 1963 and 1970, and with 1970 being the highest sales year. The decrease in sales starting in 1971 was due to the withdrawal of PCB plasticizers followed by the discontinuation of PCB-based hydraulic fluids, lubricants and heat transfer fluids.

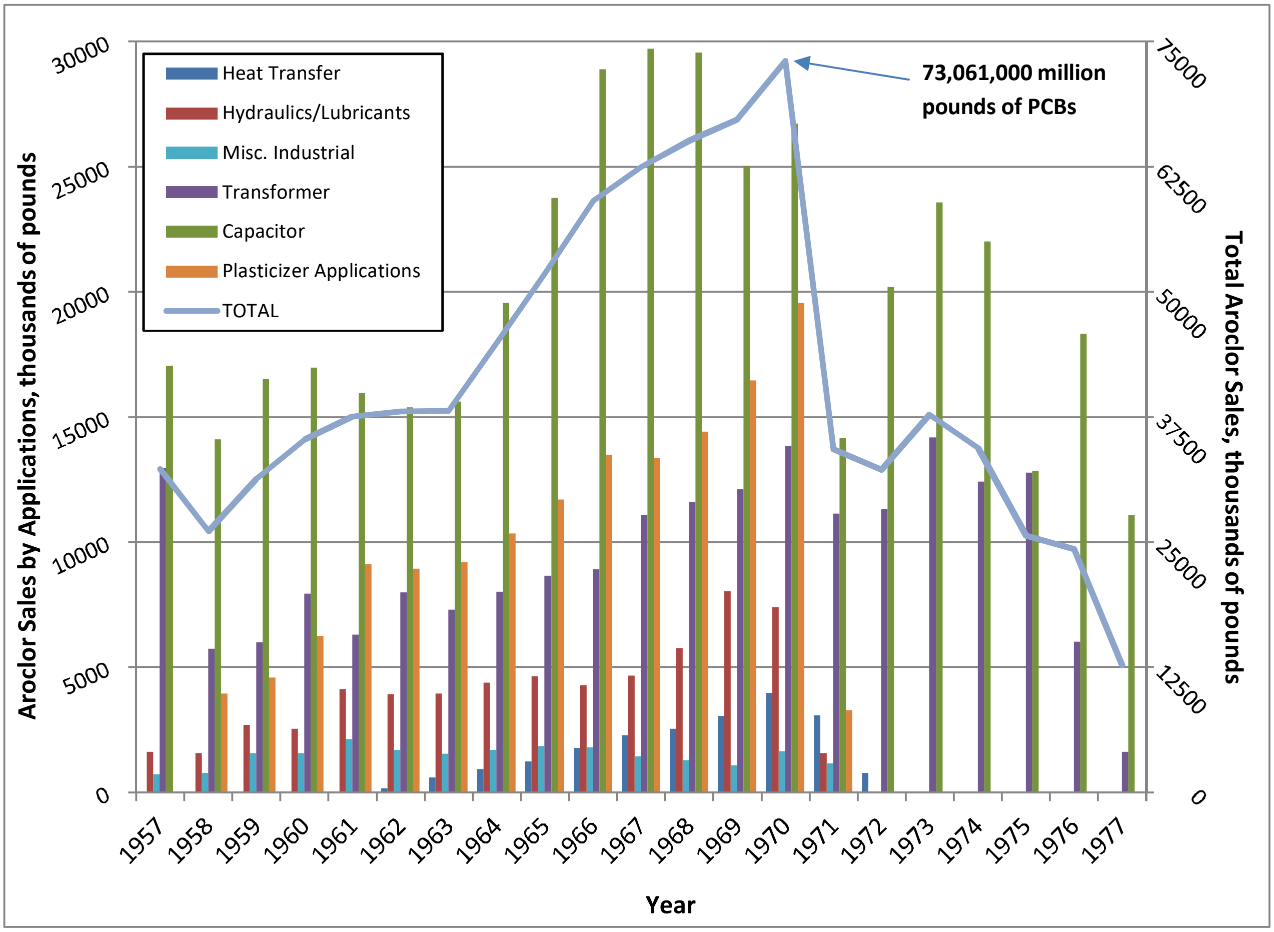

Figure 5. Monsanto's annual domestic sales of the Aroclor 1200 series by application, 1957-1977. (DSW 532590). The highest total Aroclor sales year was 1970.

Note: Records did not include sales data for plasticizer applications for 1957. The 1.4 million pounds of Aroclors sold for petroleum additives in one year (1969) is not individually shown; the amount is included in the total sales for 1969. Internally Monsanto reported it sold PCBs in Aroclor 1221 and PCTs through 12/31/1972 for plasticizer applications (HARTOLDMON0028203, no date).

In electrical equipment such as transformers and capacitors, Aroclors were used in dielectric fluids due to their low flammability and good electrical insulating properties. Monsanto sold Aroclors directly to its largest customer, General Electric (GE), who made its own transformers and capacitors and associated dielectric fluids under the tradename "Pyranol". While Monsanto sold Aroclors directly to GE, it also made Pyranol and Westinghouse's Inerteen at its PCB production plants in Anniston and Sauget and shipped the fluids to other transformer and capacitor manufacturing

facilities[11]. As shown in Figure 5, below, capacitors were Monsanto's largest market for Aroclors annually. Capacitor sales equated to almost half of its total Aroclor sales for the time period 1957-1977 as shown above in Table 2. "Of particular interest are the [small][12] capacitors used in many consumer products and appliances, including: automobiles, televisions, air conditioners, light fixtures, clothes washers and dryers, refrigerators and freezers, microwave ovens, and other home appliances manufactured prior to about 1980. The use and casual disposal of these capacitor-containing items is one reason for the widespread dissemination of PCBs into the environment." (EPRI, 1999).[13]

Although Monsanto no longer manufactured PCBs after 1977, a significant number of older electrical equipment containing PCBs are still in use (EPRI, 1999). For example, between 300 and 500 million fluorescent light ballasts with PCB-filled capacitors remain in service in buildings throughout the U.S. (Department of Ecology, 2016).

Reported sales show over 80 million pounds of the Aroclor 1200 series were used in applications such as hydraulic equipment because of their low flammability, and in heat transfer systems as a good conductor of heat in high temperature processes[14]. In both applications, PCB-containing fluids were prone to leak. Monsanto formulated and sold "ready-to-use" Aroclors and Aroclor-containing fluids for these and other "semi-closed" applications under different trade names as shown in Table 3, below (EPA, 2004). It sold PCB-containing Therminol and Pydraul until December 1971 (PCB-ARCH0633486, 12/15/71; DSW 532590, no date)[15]. Santovac and Turbinol 153, having very specific lubricant applications, were categorized by Monsanto as "Miscellaneous Industrial." Monsanto continued to sell these lubricants until early 1972 and mid-1972 respectively (HARTOLDMON0025543 @ 0035692, 2/8/1972; @ 0025688, 12/13/1971).

Table 3. Monsanto's trade names for several PCB-containing fluids used in semi-closed applications.

Trade Name	Application	Aroclors
Pydraul	Hydraulic fluids and lubricants	1232; 1242; 1248; 1254; 1260
Therminol	Heat transfer fluids	1242; 1248; 1254
Santovac	Vacuum pump lubricants	1248; 1254
Turbinol 153	Gas compressor lubricants	1221 + 1242

[11] Inerteen was Westinghouse's trade name for its dielectric fluid. The company did not blend its own fluid and instead relied on Monsanto to produce and sell it to them as well as other customers with a license.

[12] The small capacitors ranged in size from about 1 ounce to about 3 pounds (EPRI, 1999).

[13] A 1991 EPA study reported that PCBs, primarily Aroclor 1242, were found in automotive and household appliance shredder residue, known as "fluff", which was typically disposed of in municipal or non-hazardous waste landfills. The EPA estimated that over 3 million tons of fluff were produced by U.S. shredding facilities each year (EPRI, 1999).

[14] Monsanto internally reported sales of 450,000 pounds of hydraulic fluids and 170,000 pounds of heat transfer fluids were sold in 1953. The largest outlet of industrial fluids that year was for cable and wire impregnant (~ 1.5 M lbs) (PCB-ARCH0163243, *circa* 1954)

[15] Monsanto did not report any sales of Aroclors for hydraulics applications after 1971 (DSW 532590, no date).

Monsanto began selling PCBs as plasticizers in the 1930s. Although Monsanto's sales records are incomplete, the available data show that between 1958 and 1971 Monsanto sold approximately 145 million pounds of the Aroclor 1200 series as plasticizers, solvents, and modifiers for uses such as coatings, adhesives, sealants, and ink, which was used in both indoor and outdoor applications depending on the product.[16] By 1961, there were approximately forty categories of end uses for Aroclor compounds in plasticizer applications (DSW592457, 2/1961). Monsanto categorized all of these products as "open uses" because the applications interfaced with the environment[17]. Table 4, below, shows a sampling of commercial and consumer products that contained PCBs that fell under the "plasticizer" or "open use" category. A detailed description of the consumer, commercial and industrial use of several of the products and how the PCBs had the potential to contaminate the environment is provided in EPRI (1999).

[16] Monsanto began promoting PCBs as plasticizers in the early 1930s, therefore this number would be greater had it included sales from the early 1930s through 1957. Monsanto internally reported sales for this category in 1953 totaling approximately 5.4 million pounds. Applications included adhesives; water proofing and sealing compounds; non-vinyl fabric coatings; industrial protective coatings and decorative coatings (over 2.8 M lbs); lost wax for precision casting; marine paints; vinyl foam and molding compounds; vinyl film, coated fabric and extrusions; cable and wire lacquers; and miscellaneous. "Aroclor sold to plasticize Saran" were 1.5 million pounds annually (PCB-ARCH0163243, *circa* 1954).

[17] For simplicity, the term "plasticizers" represent plasticizers, modifiers and solvents throughout this report.

Table 4. PCB Concentrations in Select Consumer and Commercial Products[18,19]

Product or Material	PCB Concentrations, %
Investment casting waxes	up to 40%
Thiokol-rubber sealants	up to 40%
Polysulfide caulking	15 - 20%
Building caulking	10 - 20%
Chlorinated rubber coatings	20 - 40%
Grain silo sealants	up to 19%
Marine paints	5 - 13%
Chemically resistant paints	6 - 11%
Concrete sealant paints	9.4%
Steel swimming pool top coat paints	8.0%
Steel swimming pool primer paints	5.6 - 6.4%
Hot-dipped metal paints	7.7%
Zinc-based primer paints	3.0%
Cutting oils	5 - 10%
Wood floor finishes	8.0%
Outdoor wood furniture lacquers	4.8%
Carbonless carbon paper	3.4%
Epoxy resins	up to 1.5%
Cambric (fabric) insulating tapes	up to 1.0%
Powdered detergent (deduster additive)	0.7%

In its Plasticizer catalog, Monsanto stated it had "pioneered the technology of plasticization" in the 1930s and could "provide much more than simply the [plasticizer] products: specifically adroit, expert guidance in their use. . . .Many large resin processors look upon Monsanto's PLASTICIZER COUNCIL as an extension of their own technical facilities," and "regularly consult with Monsanto's technical service whenever they have a new product in view or an improvement [was] sought in an existing product." (MONS 080627, 1961). Monsanto's research on plasticizer behavior in polymer compositions dated back to the early 1930s. It published an article in 1931 discussing the loss of PCBs from nitrocellulose lacquer, a particular type of coating. A detailed review of this article and

[18] Adapted from Table 3-12 in EPRI (1999) by conversion from mg/kg to percent. References for each entry can be found in EPRI (1999) below Table 3-12.

[19] This is not an exhaustive list of all open use applications. For example, Monsanto informed a customer that it was discontinuing its sales of Aroclor 1254 for use in industrial soaps and hand cleaner applications as of June 1, 1970 (PCB-ARCH0227299, 5/5/1970).

other literature on plasticizer properties, function and performance studies is included in Appendix B.[20]

Some of Monsanto's customers marketed products made with Aroclor plasticizers under their own trade names. For example, the Hercules Company made and sold chlorinated rubber coatings plasticized with Aroclor 1254 under the name "Parlon" (DSW 150418, 1/1/1948; DSW 592513, 4/4/1968). Monsanto helped promote Parlon for a number of applications in which resistance to flame, corrosion, acids, bases, or water were required. Surfaces included masonry, wood, metal, and fabric (DSW 592513, 4/4/1968; DSW 150418, 1/1/1948). In the plasticizer category, surface coatings were the "largest single outlet for the Aroclor compounds." As of 1961, the volume of Aroclor sales for chlorinated rubber coatings was over 500,000 pounds. For example, masonry paint (applications included concrete surfaces in contact with water – freshwater, marine, swimming pools, potable water) was one of the most common uses for chlorinated rubber coatings (DSW 592457, 2/1961).

Monsanto sold Aroclor 1242 to the National Cash Register (NCR) company to manufacture microcapsules used for the production of carbonless copy paper (CCP) also known as "no carbon required" paper or NCR paper. Monsanto categorized this application under "open uses" or plasticizers in its documents. "This use of Aroclor 1242 was not a minor use of PCBs and it had far-reaching consequences. Between 1957 and 1971, approximately 22,000 tons [44 million pounds] of Aroclor 1242 were used by NCR's Appleton Paper Division to produce about 726,000 tons [1.45 billion pounds] of carbonless carbon paper with an average PCB content in the resulting paper of 3.4% by weight or 34,000 mg/kg." (EPRI, 1999). Monsanto ceased Aroclor sales for open uses in mid-1970 to all customers except NCR for its PCB-containing carbonless copy paper. [21]

Figure 6 shows Monsanto's sales of the Aroclor 1200 series for plasticizer applications, also referred to as open uses. Monsanto began promoting the Aroclors as plasticizers in the 1930s although there is no sales data available prior to 1958. As shown in the figure below, Monsanto's highest sales of the Aroclor 1200 series for plasticizer uses was in 1970 even though it had ceased sales for this market in August of that year. Between 1958 and 1970 Monsanto's marketing and promotion of PCBs for a wide variety of uses led to a steady rise in sales with an almost quadruple (400%) increase during this period. Prior to that time period, Monsanto noted that non-electrical sales (including industrial fluids) "more than double[d] every 10 years." By 1956, non-electrical sales were estimated at over 14 million pounds.

[20] This literature review in Appendix B includes additional publications written by Monsanto employees.

[21] According to other sources, NCR purchased 45 million pounds (± 5%) of Aroclor 1242 from 1954 to 1971 (US EPA, 1976). Also, Monsanto's sales records showed over 3 million pounds of Aroclor 1242 sold for plasticizer applications in 1971, when Monsanto claimed it was no longer selling Aroclors to its plasticizer customers (DWS 532590, no date).

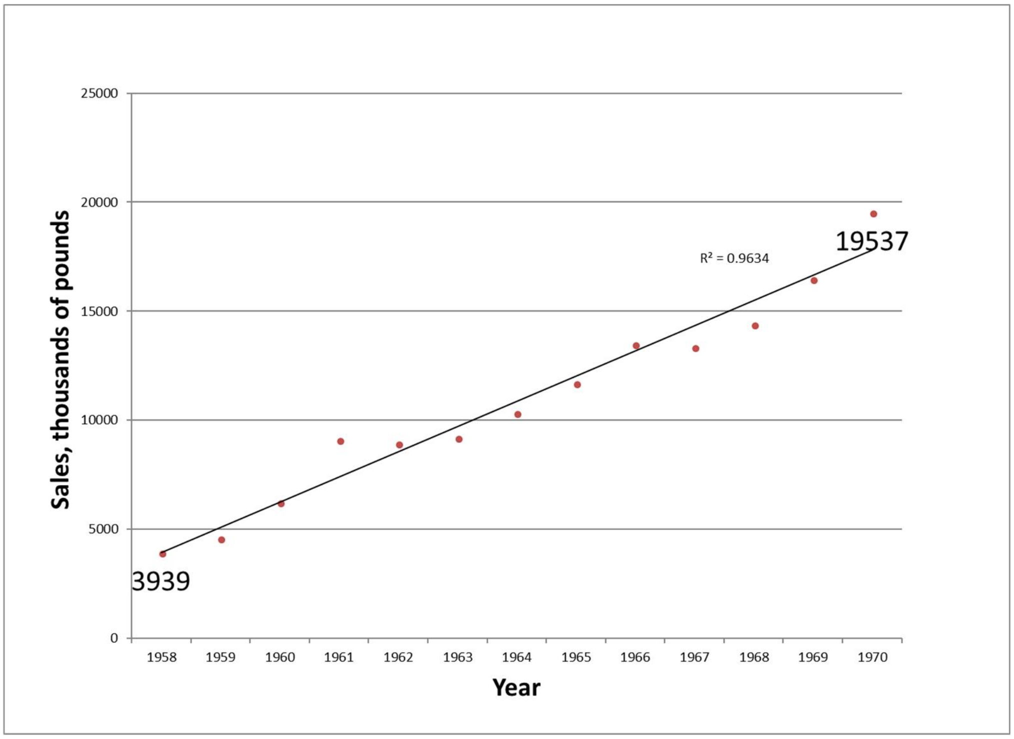

Figure 6. Monsanto's sales of the Aroclor 1200 series for plasticizer applications (open uses).

C. <u>PCBs were identified as toxic, persistent, bioaccumulative, and widespread in the environment</u>

1. Toxicity Studies

In the 1930s, several reports documented incidents of workers exposed to PCBs in industrial settings that suffered from disfiguring dermatitis, symptoms of systemic poisoning, and liver jaundice that resulted in three fatalities. Industrial hygienists and other professionals were hired to study the toxic effects of PCBs on animals as surrogates for humans and to make recommendations to avoid future incidents (DSW 002969, 5/25/1934; MON-MT-003090, 1936; DSW 001279, 6/1/1935; Schwartz, 1936a; Schwartz, 1936b; Fulton et al, 1936; Drinker et al, 1937; Bennett et al, 1938).

Some of these dermatitis incidents occurred among workers at Monsanto's PCB production plant and it was recommended to improve the ventilation, along with recommending baths and providing clean clothing daily (DSW 001279, 6/1/1935). Three young healthy workers involved in the manufacture of electrical condensers at the Halowax Corporation had died after exposures to chlorinated naphthalenes (similar in structure to PCBs) and PCBs. Industrial hygienists concluded the workers' exposure to these chemicals had caused liver disease resulting in the deaths (Greenburg et al, 2/1939).

Researchers at the Harvard School of Public Health were retained by Halowax Corporation to study PCNs and PCBs. Dr. Cecil Drinker and his team conducted experiments with rats as surrogates for humans to observe the effects at various concentrations of chlorinated compounds (including PCBs) that mirrored worker exposures. The tests involved the heating of waxes and liquids to vaporize the

chlorinated compounds, and then exposing the rats to air at ambient temperatures containing the vapors at various concentrations. They also ran feeding experiments at high doses of the same chemical compounds. (Drinker et al, 1937; Bennett et al, 1938; Drinker, 1939). The inhalation results showed that liver damage had occurred in rats exposed to low concentrations (Drinker et al, 1937; Drinker, 1939). Dr. Drinker assigned a permissible limit of 0.5 mg/cu. meter (approximately 50 parts per billion) in the workroom air for most of the chlorinated compounds with which he experimented including Aroclor 1254, and recommended that adequate ventilation be provided to prevent exceedance of that limit (Drinker, 1939). The feeding experiments with PCBs at a high dosage were discontinued after seven days when most of the rats died as PCBs proved to be "highly toxic."

The results of these experiments were presented at a symposium and a discussion about the studies was included after the published article in *The Journal of Industrial Hygiene and Toxicology*. Monsanto's Dr. Emmett Kelly participated, along with other industry representatives including General Electric, Halowax and industrial hygienists and toxicologists from state agencies.[22]

In a separate report to Monsanto approximately a year later, Dr. Drinker discussed in depth the PCB inhalation tests run the previous year. He explained, "It would seem therefore that inhalation of a concentration of [PCBs] in the manner I have described is capable of producing a condition which may be dangerous to the individual inhaling it, though of itself no visible harm will be done." Even though the rats appeared to be healthy after the 120 days, the autopsies indicated systemic toxic effects. Drinker stated "it is evident the alterations produced by this hydrocarbon are persistent and individuals who have been caused trouble by it should be removed completely and for a long time." (MONS 048123, 9/15/1938).

According to the U.S. Public Health Service, the industrial demands associated with World War II had greatly increased the use of PCBs. The hazards associated with its application had "attracted much interest and a number of reports regarding the systemic and dermatologic effects of exposure, including fatal cases, [had] been made." (Miller, 1944). For example, following "six fatal cases of a peculiar type of subacute yellow atrophy of the liver in workers at two wire and cable mills" Von Wedel et al (1943) reported on the systemic toxic effects of PCBs in the workplace at ambient temperatures. Their laboratory experiments on animals exposed to PCBs indicated that liver damage occurred in animals regardless of whether PCB exposure was by inhalation, ingestion or skin adsorption. Furthermore, the authors noted that "none of the animals showed recognizable systemic effects until a few days before death." This article also concluded "that if experimental animals react in this same way, man will also."

The American Conference of Governmental Industrial Hygienists (ACGIH) set a maximum allowable concentration (MAC) for Aroclors (in general) in air at 1.0 mg/cu. meter without an associated

[22] Dr. Kelly's comments during the discussion period were included in the journal. He stated that, "it has been our observation that although on one occasion we did have a more or less extensive series of skin eruption…we have never had any systemic reactions at all in our men." (Drinker et al, 1937). This statement did not account for Monsanto's 1935 precautionary measures for operators that included: removing all affected men from the operation and new men substituted as rapidly as they could be trained and those with dermatitis tendencies were not permitted to be employed in the Aroclor Department (DSW 001279, 1935).

temperature threshold. This value appeared in a number of publications concerning exposure of workers to PCBs in industrial settings (Brown, 1947; MONS 046928, 1949; Sax, 1951). In the "Handbook of Dangerous Materials", Irving Sax, a toxicologist with General Electric, stated that inhalation of PCB fumes can result in systemic poisoning, including liver disease (Sax, 1951).

In 1954, Yale University professors authored a paper on chloracne in seven chemical plant workers exposed to PCBs at levels of 0.1 mg/cu. meter, an order of magnitude below (or 1/10) the ACGIH recommended maximum allowable concentration of 1.0 mg/cu. meter. An unusual feature of this chloracne outbreak was the long period of low level exposure (up to 19 months) before any cases were recognized, leading the authors to conclude that "negligible amounts of chlorinated hydrocarbons indicates that this type of intermittent but fairly long continued 'mild' exposure is not innocuous." (Meigs et al, 1954).

2. Persistent and widespread in the environment

Monsanto had information at the time it began production of PCBs, that PCBs were persistent given their chemical structure. Gerald Miller, Chief Chemist for Monsanto in the 1960s, testified in deposition that the "inherent stability" of PCBs "was known probably" back in the 1930s and 1940s and agreed that it "was known early on" that stability meant they would "resist degradation." (Miller Deposition, 2001 @ 22-23).[23] Similarly, during his deposition, Dr. Kaley (Monsanto's corporate representative testifying on what Monsanto "knew") agreed that the "chemical structure of the PCBs [gave] them their persistent character" and he agreed that the "chemical structure of PCBs [had] been known since the 1800s." (Kaley Deposition, 2/19/2019 @ 20-21; 34).

In addition, Dr. Kaley testified that Monsanto's investigation and promotion of PCBs as pesticide extenders in the 1940s and 1950s indicated Monsanto had an "understanding" that PCBs would persist in the environment, and "act as a relatively permanent soil poison" (Kaley Deposition, 2/19/2019 @ 37-38; 44-45). Dr. Kaley also agreed that Monsanto "knew" since the late 1930s to early 1940s that PCBs resisted microbial degradation (Kaley Deposition, 2/19/2019 @ 51-52; 67). In a 1948 Technical Bulletin for Aroclor 1254 as a co-plasticizer for vinyl organosols (used to make free films), Monsanto highlighted several "advantages" including "Aroclor 1254 resists attack by biological influences." (DSW 550931, 11/1/1948).

The persistence of PCBs, understood by Monsanto back in the 1930s, was confirmed by others starting in the mid-1960s, when scientists began reporting on finding PCBs in the environment in Europe and in the United States. Local media outlets learned of this information and also reported on the presence of PCBs in air, trees, water, fish, birds and humans. In 1966, a number of

[23] In 1963 Monsanto reported it had developed biodegradable ingredients for detergents to address the concern with synthetic detergents not degrading in natural waters or in sewage treatment plants following disposal. It also noted that the industries supplying the persistent ingredients started researching alternatives back in the early 1950s. (WASHARCH 00198, 10/1963). This article demonstrates the chemical industry's understanding of the chemical and physical properties associated with the persistence or biodegradability of material. The method (developed by Monsanto and others in the detergents industry) to evaluate biodegradation of the detergent ingredients was later adapted by Monsanto to test the biodegradability of Aroclor (MONS 042077, no date).

publications reported on the findings of Dr. Soren Jensen, a Swedish researcher at the Institution of Analytical Chemistry at Stockholm University. At a scientific conference, Dr. Jensen presented on detecting PCBs in the environment and in humans in Sweden. PCBs were "being absorbed by water and taken up by fish and later humans." Dr. Jensen had detected PCBs in fish throughout Sweden, in a dead Bald Eagle, and in his wife's hair and baby daughter's hair, which he had concluded came from her mother's milk. The PCBs were described as difficult to biodegrade and were bioaccumulating in certain organs of animals. PCBs were also found in the air in London, England and Hamburg, Germany. One of the publications concluded, PCBs "can therefore be presumed to be widespread through the world." (New Scientist, 12/1966). A local Swedish newspaper noted that Dr. Jensen has "proved a new source of pollution of the nature." (MONS 090520, 11/28/1966). LKB, provider of the scientific instruments used by Dr. Jensen, issued a press release in January 1967 titled, "Swedish firm produces instrument that detects a previously unobserved poison in fish, fowl and mammal." The article provided depth to the methods Dr. Jensen used to detect the PCBs as separate from DDT (MONS 062162, 1/10/1967). Monsanto's European office in Brussels informed Monsanto Headquarters of Dr. Jensen's research and Shell Chemicals informed Monsanto that its laboratory also identified PCBs (Aroclors) and confirmed the "soundness" of Jensen's work (MONS 090520, 11/28/1966; Plaintiff's Ex. 2A09, 1/12/1967).

Following up on Dr. Jensen's work on PCBs in the environment, Dr. Robert Risebrough (a biology professor at the University of California, Berkley) detected PCBs and chlorinated pesticides (e.g. DDT) in a number of species of fish and birds along the coasts of the Western United States and Central America. He reported on the presence of PCBs in several marine, avian, and aquatic species in California as well as globally at a science conference in a presentation titled "Chlorinated Hydrocarbons in Marine Ecosystems", and also in a subsequent publication titled "Polychlorinated Biphenyls in the Global Ecosystem." He found that the PCBs affected hormonal balances in birds leading to reproductive disorders and potential extinction of species. Dr. Risebrough stated (MONS 097123, 10/21/1968):

> "[t]he polychlorinated biphenyls (PCB) occurring in fish and other marine organisms are assumed to be industrial pollutants. They are used extensively in industry as plasticizers and in the manufacture of paints, resins, electrical insulators and other products, and are available in railway car amounts. Since they are very stable, resist degradation, have significant vapour pressures, and are poorly soluble in water and highly soluble in lipid, it is inevitable that they should be concentrated in biological systems."

Dr. Risebrough disputed the argument that persistent compounds disappear with time stating, "[p]ollutants do go everywhere. Those which are non-polar, water-insoluble and which have finite vapour pressures will eventually appear in marine food chains. The DDT compounds and the polychlorinated biphenyls have already done so to an alarming degree." (MONS 097123, 10/21/1968; DSW 280820, 12/14/1968). Monsanto was apprised of Dr. Risebrough's work from a member of the National Agricultural Chemicals Association who had attended a conference where Dr. Risebrough presented his PCB findings (MONS 097123, 10/21/1968).

A number of articles reporting on Dr. Risebrough's work appeared in the popular press informing the public that PCBs were being identified as toxic, persistent chemicals found in wildlife, food, and waterways throughout the United States (Perlman, 1969; Bird, 1970; Boyle, 1970). One of first articles was published in the San Francisco Chronicle in 1969. The headline read "A Menacing New Pollutant." The author, David Perlman, summarized the research conducted by Dr. Risebrough in which PCBs were found in sea birds and were being linked to reproductive disorders (Perlman, 1969). An article published in The New York Times in April 1970 reported on the urging by New York Representative Ryan for a partial or complete ban on the use of PCBs (Bird, 1970).

Carl Gustafson, with the Federal Water Quality Administration, wrote an article "PCB's – Prevalent and Persistent" that was published in *Environmental Science & Technology*. He explained how the chemical and physical properties that Monsanto advertised as being beneficial for using PCBs in industrial, commercial and consumer products are what made PCBs "potentially significant contaminants of the environment." For example, he pointed out that the "solubility of PCBs in nonpolar solvents explains why they are readily absorbed into fatty tissue and into the liver," and that "[t]heir resistance to oxidation or other types of chemical degradation explains their persistence in the environment and accumulation in animal tissue." Gustafson also noted that because PCBs did not outwardly result in acute toxic effects on wildlife (immediate death or disease), the physiological effects would go unnoticed. Instead, the chronic toxicity of PCBs presented a "disturbing situation:" their resistance to breakdown in the environment; and their ability to accumulate to high concentrations in living systems to the point where chronic effects became evident. He summed up a primary concern with PCBs in a freshwater or marine environment as a consequence of their properties (Gustafson, 1970):

> "Because of the low solubility of PCB's in water, when a solution or dispersion of them is discharged into a river or lake, they will accumulate on the sediment in relatively high concentrations. Subsequently, they will redissolve very slowly in the water as conditions change. Therefore, it will usually take a long time to flush out a contaminated area."

As stated above, it was "known" by Monsanto much earlier that PCBs were persistent in the environment because they did not naturally degrade. Then, in 1963, Monsanto had found soil test plots that had been treated with several Aroclors (1242, 1248, 1254, 5442) back in 1939 to test their effects on termites, and the soils were still showing the presence of these Aroclors. In describing this information to Dr. Richard in 1969, Mr. Wheeler suggested collecting soil samples from these test plots to measure "loss or degradation." (TRAN 008733, 4/8/1969).

Also, in 1969 Monsanto had information that the PCBs it had discharged into surface waters from its own plants had accumulated in the sediments. For example, while discussing the discharge of Aroclor 1254 to the Escambia River from its Pensacola plant, Monsanto stated, "[a]lthough the use of Aroclor was halted immediately, we can expect the water contamination to continue for a lengthy period by leaching from the contaminated mud" (MON-MT003320, 5/9/1969).

Minutes from Monsanto's internal "Aroclor 'Ad Hoc' Committee" meeting in 1969 stated that "because the rate of natural (bio-degradation) [of PCBs] is very low, other degradation must destroy PCB equal to the rate of environmental exposure in order to avoid build-up of contamination." (MONS 030483, 9/5/1969). In a second meeting of the "Aroclor 'Ad Hoc' Committee", Monsanto "concluded" that "[t]here is no question as to the non or low biodegradability of the PCB's -- particularly the higher chlorinated members of the series including Aroclors 1254 and 1260 and probably 1248." Monsanto also gave a detailed account of the "toxicological aspects" of PCBs and chlorinated hydrocarbon pesticides noting that "data available at present indicate that PCBs may be 'moderately toxic' to man." In summarizing the meeting, Monsanto stated, "the PCB's are persistent once they become a part of the environment and the rate of degradation is extremely low" (DSW 164905, 10/15/1969).

In another internal company document, titled "Rough Draft - Outline PCB Environmental Pollution Abatement Plan" Monsanto stated that the "evidence proving persistence of these compounds and their universal presence as residues in the environment is beyond questioning." (MONS 035310, 11/10/1969). In a press release, Monsanto informed the public that "PCB is a persistent chemical which builds up in the environment." (MONS057292, 7/16/1970). After having conducted its own biodegradability studies, Monsanto informed one customer that "[e]xperience gained over many years indicates Aroclors are highly stable under all known conditions present in the environment." (MONS089527, 7/8/1970). In a written response to a query from a reporter with "Chemical Week", Monsanto stated that the "environmental problem" with PCBs was its persistence (MONS 057072, 2/19/1971).

Monsanto had collected information showing that the lower chlorinated PCB congeners in Aroclors responded to degradation differently than the higher chlorinated ones. Its own tests confirmed that PCBs were not naturally biodegradable, and also that the highly chlorinated congeners were highly resistant to biodegradation (PCB-ARCH0241548, 4/16/1970; HARTOLDMON0008115, 7/17/1970). This difference impacted the detection of Aroclor 1242 in the environment because it resembled Aroclor 1254. In a feeding study, upon giving Aroclor 1242 to birds, the residues "resembl[ed] 1254/1260." (MONS034450, 11/1970).[24]

3. Bioaccumulative and toxic to fish and other wildlife

Monsanto also had an "understanding" that certain chemical properties – namely "resistance to degradation processes" and "fat solubility" would "enable bioaccumulation" of PCBs, and Monsanto

[24] Monsanto internally reported that the lower chlorinated PCB congeners in Aroclor 1242 underwent some degradation such that upon analysis the Aroclor 1242 looked like Aroclor 1254 (PCB-ARCH-EXT0005172, 2/1970; HARTOLDMON0008115, 7/17/1970). In addition, Dr. Vodden, a PhD Chemist working for MCL in 1969, testified he was tasked to identify issues associated with PCBs in the environment in the UK. He headed the effort to define the degree of biodegradation of PCBs and found that after some degradation, Aroclor 1242 "look[ed] very much like Aroclor 1254, the product that people were claiming that they had found in the environment." He also testified that in 1969 he informed Monsanto's Dr. Kelly that "even though Aroclor 1242 was not identified as an environmental contaminant, there was no doubt that degradation of this product would eventually appear as a residue in the environment." (AMH Dec. - Dkt. 667, Ex. 22 [Vodden Deposition] 8/25/09).

"knew" about these properties in the 1930s (Kaley Deposition, 2/19/2019 @ pp. 64-65; 67). Monsanto also had information that once PCBs were in the environment, aquatic species bioaccumulated PCBs in their tissue (DSW 164905, 10/15/1969; MONS 034081, 10/29/1969; MONS 035372, 1969). A Monsanto report documenting toxicological aspects of PCBs noted that trout raised in water containing 1 ppb PCBs concentrated to 1 ppm PCBs in fish tissue in six weeks, a bioconcentration factor of one thousand (DSW 164905, 10/15/1969). In waters downstream of Monsanto's Pensacola plant, levels of Aroclor 1254 less than 1 ppb in the estuary were measured at a maximum of 2.5 ppm in shrimp (MONS 034003, 1970). In a presentation to representatives of the electrical industry, Monsanto's Manager of Environmental Control, William Papageorge, stated that PCBs had been detected in fish tissues at 50,000 times the amount found in the water environment in which the fish were exposed (ADM007693, 9/14/1971).

Monsanto also had information from fish studies showing that PCBs discharged into surface waters were highly toxic to certain species at very low concentrations. For example, juvenile shrimp were killed when exposed to only 5 ppb Aroclor 1254 (MONS 034003, 1970; DSW 164905, 10/15/1969). In another study the doses which were believed to be "OK" produced 100% kill. At levels of 1 to 10 ppm for both Aroclors 1242 and 1254, for 50 fish per level, all died (PX 4A17, 4/29/1970). Monsanto's summary of analytical findings from its Aroclor Environmental Program reported dead trout after exposure to Aroclor 1254 (DSW228377, 5/1-21/1970).

From in its own commissioned fish studies conducted in Choccolocco Creek, downstream of its Anniston PCB manufacturing plant, Monsanto had information that the fish had bioaccumulated Aroclor 1254 in the lipids in the 100s to 1000s ppm range (DSW 013505, 8/6/1970). Consultants hired by Monsanto reported that the fish below the source of PCBs in Choccolocco Creek have "concentrated the [PCB] residue to a greater degree than" the fish living above the pollution source. The consultants also reported that they "continue[d] to find deformed, sick, lethargic fishes" (DSW 013307, 6/9/1972).

Monsanto also acknowledged that not only were fish impacted from exposure to PCBs, but "there [was] ample evidence from many laboratories that certain species of birds which are at the top of the marine food chain cannot reproduce properly when PCB's are present in their diets." (MONS089527, 7/8/1970).

"From 1969 through 1971, the FDA [Food and Drug Administration] established action levels for PCBs in food at 0.2 ppm in milk, 5 ppm in edible flesh of fish, 5 ppm in poultry, and 0.5 ppm in eggs. In 1970, the FDA prepared a summary of the available information on the chemistry and toxicity of PCBs." By 1972, a great deal of research had been completed on PCBs and was summarized in various review articles covering their toxicity. "In 1973, the FDA formally established limits for PCBs in food and animal feed." (US EPA, 1979).

The Interdepartmental Task Force on PCBs (ITF), comprised of federal agencies, was formed in 1971 to study the potential hazards of PCBs to humans and the environment (ITF, 1972). The ITF report stated, "PCBs can be lethally toxic to some fish and aquatic invertebrates when concentrations in

the water are parts per billion or less. They are metabolized and excreted very slowly by these organisms . . . the evidence for toxic and physiological effects indicates that the PCBs must be viewed as potential problems at present environmental levels" (ITF, 1972, pp. 18-19). The scientific literature cited in the report showed toxic effects from PCBs on oysters, shrimp, pinfish, spot, and rainbow trout (Duke, et al. 1970; ITF, 1972, pp. 161-167).

In addition, Monsanto possessed a 1972 article published in "AMBIO – A Journal of the Human Environment, Research and Management" in its files that reported on the mass PCB poisoning of salmon resulting in death at a Swedish hatchery. The source of PCBs was traced to anti-fouling paint used in a fish hatchery (DSW280873, 8/1972).

When Gustafson's article was published (Oct. 1970), the author had added a side note stating that Monsanto informed Congressman Ryan (of NY) that it would cease sales of PCBs to customers for plasticizer uses. Monsanto did discontinue sales of the Aroclor 1200 series for "open" uses such as plasticizers effective August 30, 1970.[25] Monsanto also discontinued sales of the Aroclor 1200 series for "semi-closed" uses in hydraulic equipment and heat transfer systems by 1972 and all PCB-containing products in 1977. Congress specifically banned the manufacture of new PCBs, and prohibited the processing, distribution in commerce and use of PCBs "in any manner other than in a totally enclosed manner" under Section 6(e) of the 1976 Toxic Substances Control Act (15 U.S.C. § 2605(e)(2)(A)).

D. Sources, Fate and Transport of PCBs in the environment

Research from the 1970s through today has identified various legacy PCB sources to the environment as well as the mechanisms/transport processes for the continued release and spread of this contamination through pathways such as stormwater runoff and atmospheric transport. Anywhere PCBs were used in open use applications including caulks, paints, and plasters for building construction are continuing sources of PCB contamination in the environment throughout the world. (Refer to Appendix C for a more detailed analysis.)

VIII. Literature defining corporate social responsibility and Monsanto's own corporate positions on social responsibility.

Information pertaining to safe products, environmental protections and open relationships with the government, customers and the public coupled with Monsanto's own corporate positions on social responsibility established the standards by which Monsanto must have known to follow with respect to its promotion and sales of PCBs and its handling of the PCB environmental problem.

A. Industry standards on corporate social responsibility.

The role and responsibility of corporations in the United States was defined in historical documents and texts by the chemical manufacturing industry, and corporate representatives and other

[25] Monsanto informed its customers that it would continue to sell Aroclor 1221 (Kaley Dep Ex#15, 6/26/14).

professionals engaged in industry's protection of the public health and the environment from products. The National Paint, Varnish and Lacquer Association stated in a "Not for Publication" letter to its members, "Toxic materials with their ever-present problems require our conscientious consideration of the fundamental principles involved. . . . The vital factor concerning toxic materials is to intelligently safeguard the public." (NCA, 7/18/1939). The last page of the letter included the Manufacturing Chemists' Association, (an industry group of which Monsanto was a member), legal principles as guidance for its members concerned with labeling to safeguard the public. Some examples include (NCA, 7/18/1939):

> "A manufacturer who puts out a dangerous article or substance without accompanying it with a warning as to its dangerous properties is ordinarily liable for any damage which results from such failure to warn."

> "The manufacturer or one who holds himself out to be the manufacturer must know the qualities of this product and he cannot escape liability on the ground that he did not know it to be dangerous."

Another organization, the National Society of Professional Engineers (NSPE), was formed in the 1930s. Before its constitution was adopted in September 1934, the society's delegates adopted ten objectives. The objectives included" promoting the public welfare," and supporting state legislation "protecting the public welfare" (Robbins, 2017).

Theodore Houser, chairman of Sears, Roebuck and Company, made a number of statements on how corporations relate to the community, the government and the public in order to better both the company and the public. He stated in "Big Businesses and Human Values" Houser (1957):

> "Businesses, no matter how big are accountable to many groups beyond the confines of their own organizations. . .customers, the community, the public at large. . . .The relationships of the corporation with the community, the public and the government are less direct but not less real, and need to be given thought as part of the broad spectrum of management responsibility.

> "The responsibility of a business to the community in which it operates is primarily social in character. This responsibility is comparable to that of any private citizen, and is not essentially altered by the fact of corporate rather than individual personality. In many ways the obligations of the corporate citizen are greater and more far-reaching than those of individual citizens simply because of the corporation's greater resources, in terms not merely of money but of special skills and experience."

> "It can see its customers not as objects of exploitation, an inanimate resource, but as people who will be better customers the better informed they are. It can show in its relations with other businesses dependent upon it a willingness to develop independent self-generating entities and thus engender a healthy increase in the social and the economic potential of the community. And while paying the necessary respects to facts, figures, and profit-and-loss

statements, every business can see itself not only as a producer of goods and services but as a citizen as well."

In the book, "Managing The Socially Responsible Corporation", Carl Gerstacker, Dow Chemical Company's Chairman of the Board from 1960 to 1976 authored a chapter titled "Creating a Management Environment for Socially Responsible Performance." Under the chapter section, "Creating the Socially Responsive Environment," he defined three "critical postulates for creating a socially responsible management environment within a corporation" (Gerstacker, 1974):

- "Social responsibility must be a firm, deep seated belief of the management. It must be soundly and deeply a part of the on-going goals and strategy of the corporation. Unless there is a genuine commitment on the part of the management this is not going to happen."
- "Management must be consistent in its support of social responsibility."
- "Management commitment must be long-term."

He also described how chemical companies have gained considerable information about their products, the potential for environmental contamination and how to mitigate such contamination. He stated:

"Dow makes some 1,100 different products, many of them highly hazardous, and in making. . . these products. . .some are bound to spill and some to spoil, creating pollution problems of a major magnitude. . . .The silver lining. . . is that because we have so many problems we also know more than most about handling pollution. . . .Our background in environmental matters, in short, was soundly based and solidly established by the time environmental contamination became a front page topic about ten years ago."

"Much of our current effort is being devoted to what we call "product stewardship." This is an important aspect of social responsibility. As we define the concept, it means that we have a responsibility for a product every step of the way, in manufacture, in shipping and distribution, in its use, and on to its final disposal. Our marketing people work with our customers so that safe handling, safe use, and safe disposal are hallmarks of our activities, and so that our products are not used in ways not intended or tested for. Our manufacturing people are concerned not only with meeting our pollution control standards but with safety in the packaging and movement of goods. Our research and development personnel emphasize safe products, environmentally sound products, and part of their responsibility is to develop information for safe handling, use, and disposal of our products."

Clark Abt, described as "an engineer, environmentalist, entrepreneur, educator and social scientist" also authored a chapter in the book "Managing The Socially Responsible Corporation"[26]. In the chapter, "The Social Audit Technique for Measuring Socially Responsible Performance" he outlined

[26] Dr. Abt founded Abt Associates and served as the President from 1965 to 1985. The Abt Associates website has a full career profile for him. http://abtassociates.com/About-Us/50th-Anniversary/Presidents/Clark-C--Abt.aspx

the "five publics most affected by the activities of corporations", which were "the employees, the owners, the customers, the residents of the corporation's local environments, and the general public." In defining corporate social responsibility, he made several relevant points that had either widespread or major agreement among corporate managers with respect to corporate responsibility (Abt, 1974):

- "honest, truthful, and fair dealings with other enterprises, consumers, and employees"
- "complete truthfulness in advertising"
- "nonharmfulness of products and services"
- "obeying all laws, including those weakly enforced ones against pollution, unsafe practices…, etc."

In the same book, entrepreneur, Dan Lufkin, head of the Connecticut Department of Environmental Protection at the time, wrote a chapter titled "Some Financial Implications of Corporate Social Responsibility." He stated (Lufkin, 1974):

> "Industry will be charged not only with the responsibility for providing goods and services, but also for assuring goods that are safe and well constructed and services whose latent effects are not harmful. If in the process of manufacture, industry pollutes the air and fouls the water, industry will be expected to bear the major costs of cleansing the air and water and restoring and returning them to the public in usable if not mint condition."
>
> "It is not enough for top management to want to do good. The corporate system is designed to thwart activities which divert resources from short-term profitability unless they are given sufficient funding, unless they are assigned enough skilled people, and unless the socially responsible activity becomes a standard of evaluation against which staff and line executives can expect to be measured, compensated, and advanced."

B. <u>Monsanto's corporate positions on social responsibility.</u>

Monsanto defined its own responsibilities to consumers, communities, the public and the environment through its corporate position statements. In 1947, Dr. Kelly gave a presentation at the annual meeting of the American Public Health Association. In a news release Monsanto paraphrased Dr. Kelly's talk stating, "The industrial chemical field, Kelly asserted, is broadening too rapidly and too extensively for toxicological investigations to keep apace. Although many new products are being developed by manufacturers, the problem is to make certain that no new chemical is used in a manner in which systemic toxicity or skin irritation might result either in workers making the product or in consumers." (Monsanto, 10/7/1947).

Monsanto's business principles were updated and supplemented in the 1950s, 1960s and 1970s. They were very much in line with the historical guidance described above. The 1954 Guide for the Medical Department stated it "shall coordinate the air and stream pollution aspects of waste disposal activities." (TOWOLDMON0016531, 1954). The Medical Department was deeply involved in

PCB product toxicity related to worker issues starting in the 1930s and took the lead in handling PCB environmental issues in the late 1960s.

The 1966 Monsanto Management Guide stated that "[i]n relations with plant communities, we will. . . cooperate with all properly constituted authorities to reduce air and stream pollution." (TOWOLDMON0020039, 1966). This guide had been updated a number of times in the 1960s. Concerning communities, several versions stated that Monsanto was "to be a substantial contributor to the general welfare of society." (TOWOLDMON0017349, 7/15/1960; TOWOLDMON0018008, 4/1962; TOWOLDMON0018192, 4/1963).

Concerning stream pollution, a senior vice president with Monsanto issued a news release in 1969 urging industry to "reduce the nation's water pollution to acceptable levels by 1980" (WASHARCH 00229, 10/7/1969).

In 1970, Monsanto's business principles stated in part, "[i]n our growth, we will strive to . . . develop products and services which will provide value and safety for the ultimate consumer and will not adversely affect the ecological balance of our planet." (TOWOLDMON0018399, 2/1966 @ 18417). This sentiment was repeated by Monsanto's Chief Executive John Hanley in a radio show segment on PCBs in the environment. Hanley stated (MONS 000403, 12/19/1977):

> "The guy that's got the responsibility for the safety of our product is Monsanto. . . .We cannot and have no interest in dodging the ultimate responsibility for the safety of our products, our processes, and the eventual disposition of those products. . . .No one else can set that standard as high as we should set it for ourselves and that's the way we conduct our business."

According to Dr. Scott Tucker, a former Monsanto employee, this responsibility was held by Monsanto in its early years of making PCBs. In deposition, he agreed that "when Monsanto manufactured PCB's back in the 1940's and '50s" it was the "duty of the manufacturer to manufacture a safe product." (Tucker Dep, 1/5/1999 @ 89). Thus, the Ad-Hoc Committee concluded "Monsanto is most probably responsible for the U.S. contamination and jointly responsible with MCL for the United Kingdom problem" (MONS 035372, *circa* 1969).

Monsanto issued a number of policy statements beginning in 1971. Mr. Michael Pierle, Monsanto's Corporate Representative testified that the 1971 policy was in place during the entire time Monsanto manufactured and sold PCBs (TOWOLDMON0046444, 7/10/2006). The 1971 policy stated that Monsanto "has always recognized its responsibility to the public, to its shareholders, to its employees, to its customers and to the communities in which it operates." These responsibilities included concern for the public interest, environmental pollution, and cooperation with the government and regulatory bodies. Under "Environmental Evaluation of Proposed New Products and Processes", "Monsanto, recognizing the need for control and reduction of environmental degradation, diligently and systematically assesses the impact of proposed new products and processes on the environment." The pollution control policy in the document stated: "A. Always be concerned for the public interest. . . . F. Cooperate with appropriate government agencies, including participation in the development of rules and regulations." (DSW 117325, 7/1971).

Monsanto's executive, Mr. Papageorge, who was plant manager at its PCB manufacturing facility in Anniston, Alabama from 1965 to 1970, Manager of Environmental Control in 1971, and Head of Monsanto's Ad Hoc Committee stated that chemicals such as PCBs should not be released into the environment. He testified in deposition (Papageorge Deposition, 1993):

> "At a minimum, it is just not prudent to discharge knowingly any kind of industrial chemical, whether it be PCBs or any other material…you wouldn't want to discharge out into the environment. It just wasn't a practice that was considered to be responsible."

Monsanto's position in 1974 emphasized product quality and safety through research and testing, and maintaining "open communications with all national and local authorities, employees, customers and publics". The 1974 policy statement specifically noted that Monsanto "will market products under conditions which promote safe handling and use." (DSW 117818, 7/1/1974).

Monsanto also issued "Social Responsibility Policy Statements" in 1977 in which it stated, "[w]e will adhere to all laws governing corporate conduct, but we will not hesitate to go beyond legal requirements, if, in our prudent judgement, a higher level of performance is in order. . . We will regularly modify and refine our corporate posture in these public policy areas to remain responsive to the legitimate demands of the world in which we do business." (TOWOLDMON0047829, 11/1977).

In the radio show segment on PCBs in the environment, radio host Hardy, paraphrasing Monsanto's Director of Social Responsibility, Anna Navarro, said: "that. . .is one of the lessons of PCB's. Good ethics, she claims, is good business. And she points to the millions of dollars of lawsuits filed against the firm on PCB's." According to Navarro, "We realized that the social consequences of staying in that business were such that it was no longer a profitable business. We ought to get out." Hardy wrapped up the segment by again paraphrasing Navarro when he stated, "It is more than time, she says, for business practices to come into step with ecological concerns." (MONS 000403, 12/19/1977).

With regard to ecological concerns, Monsanto acknowledged that the persistence of PCBs in the environment would be "with us for decades" and the question of who is responsible will continue to be asked." Building on Monsanto's expertise and financial resources, Monsanto employee Wilkins proposed a "major research effort to seek new ways to treat PCB wastes." His goal was two-fold: to show the public and government it was taking responsibility for the PCB problem, and to create a new market if it found a solution to treat PCB wastes (DSW 266487, 11/28/1977).

In 1980 Monsanto discussed establishing a policy for the company's "environmental and health accountability" for discontinued products because the "environmental legacy" of such products (and associated wastes) "may require subsequent action by the corporation." The "General Policy" stated "Monsanto [would] act in a responsible manner in the management of its discontinued products." A number of action items to support that policy were listed including approval of "plans and strategies to deal appropriately with discontinued products which may pose substantial danger to health and the environment." Monsanto acknowledged that some of its products may be "found persistent in

the environment after use or disposal" and that efforts may be made to hold Monsanto accountable for environmental and health effects of discontinued products for so long as they exist in the environment." (PCB-ARCH0742044, 2/15/1980).

PCBs fell under Monsanto's new policy on discontinued products. The company stated it would "maintain [a] strong Corporate commitment to managing polychlorinated biphenyls." It also stated it would "act in a socially responsible manner" concerning PCBs by (1) establishing a center of expertise to manage "technical, health, safety and environment data" on PCBs, (2) continuing research on the health and environmental effects of PCBs and "handling and disposal technology", and (3) establishing a management plan for all aspects of PCB materials "in perpetuity." (PCB-ARCH0742061, 6/24/1980).

Monsanto's 1990 "Pledge" stated that its promise to "reduce all toxic and hazardous releases and emissions, working toward an ultimate goal of zero effect; ensure no Monsanto operation poses any undue risk to our employees and our communities . . . ." (no Bates #, January, 1990).

Monsanto also had the expertise and opportunity to investigate potential impacts of PCBs on the environment. In 1951, Monsanto hired Mr. Jack Garrett, an industrial hygienist, as an air and water pollution specialist in the Medical Department. Mr. Garrett wrote an article in 1957, "Toxicity Considerations in Pollution Control," which described Monsanto's methods of determining the effects of discharges from one of its own chemical manufacturing facilities. He noted that toxicity data was available through animal feeding studies, but the "most serious toxicity problem" was the effect on aquatic life. He presented a detailed case history on Monsanto's acrylonitrile production facility and the installation of a waste treatment plant to control discharges of chemical wastes into a bay. Experiments on fish to determine acute toxicity of various concentrations of chlorinated compounds were described. Mr. Garret explained that the tests had limitations because they did "not take into consideration the effect on the predatory cycle" in the receiving waters. Garrett lamented "the lack of comprehensive data on the effects of industrial waste on living organisms." (Garrett, 1957).

IX. <u>Monsanto promoted and sold PCBs as plasticizers for uses open to the environment.</u>

Monsanto promoted and sold PCBs as plasticizers for open uses (applications that interfaced with the environment) starting in the early 1930s and continuing into 1970 despite the scientific and technical information that existed at the time that PCBs would inevitably migrate away from those uses, resulting in persistent and widespread contamination. Monsanto created and sustained the PCB market for these applications without providing sufficient information to its customers that PCBs would continue to migrate out of these applications and into the environment which resulted in exposures to the public and the environment.

A. <u>Toxicity and safe handling information in Monsanto's early promotional material for Aroclors, plasticizers, and products containing Aroclors.</u>

In 1930, shortly after PCB production began, an article by Swann highlighted the physical and chemical characteristics of PCBs and described a diversity of potential uses for PCBs such as protective coatings like varnishes and lacquers, printing inks, artificial leather, and rubber cement, which would expose consumers or the environment to PCBs through plasticizer loss from these products. In terms of worker health, the article noted that the concentrated vapors were irritating to the nasal passages and caused violent headaches to certain persons (Penning, 1930).

In 1937, Monsanto employee L.A. Watt wrote a memo with phrasing that "could be used" in Monsanto's promotional materials and customer communications. The memo stated (MONS 219708, 10/11/1937):

1. "Experimental work in animals shows that prolonged exposure to Aroclor vapors evolved at high temperatures or by repeated oral ingestion will lead to systemic toxic effects."
2. "Repeated bodily contact with the liquid Aroclors may lead to an acne-form skin eruption."
3. Suitable draft ventilation to control the vapors evolved at elevated temperatures as well as protection by suitable garments from extensive bodily contact with the liquid Aroclors, should prevent any untoward effect."

Although Dr. Drinker's work revealed that prolonged exposure to Aroclor vapors could lead to systemic toxic effects, temperature was not part of his analysis. As discussed earlier in this report, the Aroclors were heated to accelerate volatilization for the purpose of the study, but the vapors were then mixed with ambient air for the animal experiments.

Monsanto's product information published in the 1940s recommended PCB-containing Aroclors as plasticizers in a number of applications including plastics, pigments and different types of coatings for a variety of surfaces (e.g. wood, metal, brick, stone, concrete and fabric) (TOWOLDMON0039017, 5/1940; MONS 092643, 10/1/1944; MON-MT-001598, 6/18/1945; DSW 150418, 1/1/1948; MONS 078331, 4/4/1949). Monsanto's Technical Bulletin titled "Aroclor resins and plasticizers for Chlorinated Rubber" issued in 1948, specifically recommended uses that had the potential for PCBs to come in contact with humans, wildlife, and the environment, such as concrete swimming pools, traffic paints, coatings for cloth, and marine finishes. The applications recommended in these various bulletins allowed PCBs to migrate into the environment, whether that environment was indoor or outdoor air, water or another adjacent solid. The toxicity warnings were solely focused on workers with no mention of dangers to the ultimate consumers, the public, and the environment.

Monsanto released a 1948 Technical Bulletin for Aroclor 1254 as a co-plasticizer for vinyl organosols in 1948. Organosols were used to make "free films for shower curtains, rainwear and to coat fabrics used for upholstery, . . .for coating paper in making draperies, table cloths, etc." (DSW 550931, 11/1/1948). All of these products had great potential for end-user exposure to PCBs. Another

example of Monsanto's promotion of Aroclors in products with end-user exposure was illustrated in the Technical Bulletin titled "Aroclor 1254 Lubricant and Plasticizer in the Manufacture of Paper Draperies" issued in 1949. It promoted PCBs and "the popularity of paper draperies in this country. . . ." A section was devoted to worker health with respect to dermatology and toxicology, but contained no warnings about household or consumer exposures to PCBs volatilizing from the draperies into the indoor air (MONS 078331, 4/4/1949).

The toxicity section in Monsanto's 1945 bulletin titled, "The Aroclors, Physical Properties and Suggested Applications, stated "[e]xperimental work in animals shows that prolonged exposure to Aroclor vapors evolved at high temperatures. . .will lead to systemic toxic effects" and that "suitable draft ventilation to control the vapors evolved at elevated temperatures. . .should prevent any untoward effect."[27] The first sentence of the section following "toxicity" stated, "Aroclors have low vaporization losses," with the graphs showing vapor pressure as a function of temperatures all above 125°C (257°F) (MON-MT-001598, 6/18/1945).

The information presented in this toxicity section was misleading because it implied that harm only occurred at elevated temperatures, when in fact Dr. Drinker's experimental work on animals was conducted at ambient temperatures. The animals were not breathing in air at temperatures above 257°F. Dr. Drinker heated the waxy and resinous PCBs in order to accelerate the accumulation of PCB vapors which did not alter the chemical structure or toxicity of the PCBs. The PCB vapors were then mixed with ambient air to the desired concentrations for his experiments. As noted earlier, Dr. Drinker recommended 0.5 mg/cu. meter as the permissible limit for Aroclors without any temperature thresholds.

In addition to Monsanto's bulletins and catalogs, a number of advertisements for Monsanto's PCB-containing Aroclors appeared in the periodical, *Chemical and Engineering News*, a trade magazine containing professional and technical information for chemical industry. The promotional material suggested a wide range of applications for Aroclors, including plasticizers uses, and emphasized the stability of Aroclors with statements such as "They give paints greater toughness and adhesion . . . stronger resistance to corrosion, flame, water and weather . . . greater resistance to acids and alkalies." (C&E News, 9/25/1950). These advertisements did not contain any information concerning toxicity or persistence (C&E News, 5/29/1950; C&E News, 8/25/1952; C&E News, 2/26/1951; C&E News, no date).

Monsanto also promoted the use of Aroclors (PCBs and PCTs) in insecticides as solvents, carriers and extenders. For example, in 1948 Monsanto studied the use of Aroclors as a solvent for its own DDT, which Monsanto sold under the tradename "Santobane" (PCB-ARCH0043462, 6/28/1948; PCB-ARCH0043461, 7/6/1948). Then, in Monsanto's promotional material for Santobane, it included Aroclors 1221, 1242, 1248 in a list of solvents compatible with DDT. The section titled "Instructions for Handling Santobane" had safety and toxicity information for DDT but did not contain any toxicity

[27] The statements in the toxicity section were copied directly from the 1937 language prepared by Watt (MONS 219708, 10/11/1937).

information for any of the solvents included in the promotional material. The only cautionary statement concerned flammability, which would only apply to certain solvents and not the Aroclors (WATER_PCB-SD0000078216, 1951). As noted above, Monsanto had information concerning toxicity of Aroclors.

The research on Aroclors with lindane and similar insecticides was conducted by Monsanto and the United States Department of Agriculture (USDA). Although Monsanto's research did not show much improvement by formulating lindane with Aroclors, the USDA had promising results on non-porous surfaces such as metals and glass (HARTOLDMON0005062, 4/14/1954; PCB-ARCH0042797, 4/28/1954; MONS034033, 6/30/1955). In fact, Monsanto informed the USDA that it had "sold truckload amounts of Aroclor for use in combination with Lindane and other insecticides." Monsanto also reported internally that the USDA was "not aware that their work has led to commercial value." (MONS034033, 6/30/1955).

A Monsanto sales report discussed Aroclor 1262 potentially being sold for a Lindane insecticide formulation for household use. The customer was waiting for state approval for the product before proceeding with the purchase of 600 to 1200 pounds Aroclor 1262 per week for a total of 10 to 12 weeks (a range of 6000 to 14,000 pounds Aroclor 1262). The formulation was used in conjunction with a lightbulb such that the heat from the bulb would cause volatilization of the mixture (PCB-ARCH0042594, 6/10/1954). Despite Monsanto's information about PCB toxicity exacerbated by the heating of Aroclors, Monsanto did not have any reservations about this potential open use application.

In 1956, a Monsanto employee internally reported on a meeting with USDA personnel concerning studies on chlorinated hydrocarbon insecticides formulated with Aroclors. Having learned of promising results, the memo stated that "before pesticide formulations containing Aroclors could be sold, it would be necessary to clarify Aroclor residues on plants and animals." (PCB-ARCH0042933, 2/21/1956). A 1957 Monsanto report titled "Aroclors as Agricultural Chemicals" presented Monsanto's research on the effectiveness of Aroclor-insecticide formulations. This report was written many years after several Aroclor-insecticide formulations had already appeared on the market in the late 1940s for livestock pest insecticides (DDT / Aroclor), soil insect control, miticides and rodenticides (PCB-ARCH0043485, 4/1/1957). The report noted that "approximately 135,000 pounds of Aroclors to date" had been sold for "proprietary insecticidal products" and that the use of Aroclors in such products "would necessitate extensive toxicological and residue studies for U.S.D.A – F.D.A registration to conform to requirements of the Miller Pesticide Residue Amendment."[28] In order for Monsanto to register Aroclors for agricultural use, the report stated that it would need to spend around $30,000 on two-year chronic toxicity feeding tests to generate toxicological data as a part of the registration requirements. Furthermore, the report noted that Monsanto did not have

[28] The Miller Pesticide Residue Amendment "spells out procedures for setting safety limits for pesticide residues on raw agricultural commodities" (USFDA, 2/1/2018).

any information on "exposure of spray operators applying agricultural pesticides." (PCB-ARCH0043485, 4/1/1957).

Based on his research, the author of the report (Monsanto employee J.M. Magner) recommended that the company discontinue funding its own research on the use of Aroclors as pesticides and pesticide extenders but continue to cooperate with others studying termite control, mammal repellent and seed treatment (PCB-ARCH0043485, 4/1/1957). The report contained a detailed summary of Monsanto's prior tests involving Aroclor containing products (bactericides, fungicides, herbicides and insecticides), state sponsored tests from around the country on Aroclor containing insecticides, and various other studies (molluscacides, nematocides, rodent repellents, seed and soil treatments, wood and soil treatment for termites). Also included was a list of Aroclor sales for the years 1953 through March, 1956 containing Monsanto's customers, the amount of Aroclors (PCBs and PCTs) purchased and the agricultural use of the Aroclor products. Of the more than 147,000 pounds of Aroclors sold during this time frame, 143,000 pounds were PCB Aroclors (PCB-ARCH0043485, 4/1/1957).

A few months later, Monsanto employee L.V. Sherwood wrote an internal memo condemning Monsanto's recommendation to sell Aroclors as an extender in Lindane without a restriction for spraying on feed and food crops, a use that did not have U.S.D.A. / F.D.A. approval. Mr. Sherwood was referring to Monsanto's "PCB Sales Information Bulletin", dated August 27, 1957. He stated because this use did not have governmental approval salesmen should be aware of that and should apprise their customers. Sherwood explicitly stated that "Aroclors are toxic" and data on residues would be required by the government. He also stated that "if a toxic quantity of Aroclor" residue is present on food or feed crops at harvest time, a tolerance for Aroclor could not yet be established because Monsanto had not conducted the two-year chronic toxicity feeding tests (a required test as noted in the April 1957 report discussed above). Sherwood indicated that these tests and other information would not be necessary if the Aroclor containing insecticide was not used on food or feed crops, but the "label must show safe handling procedures since Aroclor is toxic." (MONS 092048, 8/30/1957).

Sherwood pointed out that while the August 1957 bulletin did not explicitly suggest spraying an Aroclor containing insecticide on food or feed crops, the bulletin did not explicitly state that it "<u>should</u> <u>not</u> <u>be</u> <u>used</u> <u>on</u> <u>food</u> <u>or</u> <u>feed</u> <u>crops.</u>" (*emphasis in original*, MONS 092048, 8/30/1957). He pointed out that Monsanto had found that customers will use formulations for other uses than what was specified and therefore he "strongly recommended that [Monsanto] state very specifically in any Monsanto literature, including correspondence, that Aroclors not be used on agricultural commodities." (MONS 092048, 8/30/1957).

A review of Monsanto's Technical Bulletins from 1960 clearly demonstrate that Monsanto ignored Sherwood's recommendation. For example, the technical bulletin "Aroclors" had a section describing the beneficial use of Aroclors 5460 and 1254 as vapor suppressants in insecticides, including increasing the effectiveness of lindane when used on hard surfaces. The section also stated "Aroclors are recommended for chlorinated insecticide formulations to be used for non-crop

spraying." (TOWOLDMON0029987, 5/1960). Clearly this statement is similar (if not identical) to the 1957 PCB sales bulletin and was not updated based on Sherwood's memo.

Similarly, the technical bulletin written for the plasticizer market "Aroclor Plasticizers PL-306" contained a section titled "Vapor Suppression (for longer insecticide kill-life)" that promoted the use of Aroclor 5460 in lindane for hard surfaces. The section also contained the following statement: "Aroclor 5460 is also recommended for noncrop insect formulations containing chlordane, aldrin and dieldrin. The other resinous Aroclors (1254, 1260, 1262, 4465 and 5442), also non-volatile and sticky or tacky, likewise merit evaluation as insecticide extenders." (DSW352447, 12/1960). Clearly, this statement was similar (if not identical) to the 1957 PCB sales bulletin and was not updated based on Sherwood's memo.

The toxicity sections in both 1960 bulletins informed customers that at "ordinary temperatures" Aroclors "have not presented industrial toxicological problems", yet Monsanto did not have any toxicological information related to pesticide spray operators or consumers of crops with Aroclor residue as noted previously by Sherwood in 1957.

More promotion for using Aroclors in insecticides appeared in a 1961"Chemical Specialties Data Report" that was written for customers to aid them in their "evaluation and development of special uses for Monsanto products." This document discussed using "Aroclor/lindane formulations" on the "inside of garbage can lids, window screens, doorsills, the painted wall of outbuildings, diary plants, storage areas, etc" in order to control pests. Packaging in "shoe-polish type" bottles, "aerosol spray cans and bulk packages for mechanical spray application" were suggested (TOWOLDMON0043718, 3/1961). The report contained a long list of advantages to using Aroclors, a number of example formulations with Aroclors, and positive experimental results. However, no toxicity information for its customers or potential users was included.

B. <u>Scientific studies conducted by and for Monsanto evaluated PCBs' vapor pressure, volatilization, loss rate, persistence and toxicity.</u>

It is a scientific fact that materials with a vapor pressure, even a considerably low one, will volatilize. The rate or amount of volatility is dependent on the vapor pressure and other factors. As explained earlier, PCBs are mobile. They will volatilize into the air or leach into an adjacent material. The 1931 article cited earlier showed that when used as a plasticizer in a final product (nitrocellulose lacquer), PCBs would escape from that final product.[29] In the early 1950s, customer inquiries led Monsanto to conduct a series of tests at its own plants to determine indoor air concentrations of Aroclor after applying Aroclor containing paint, and during the production of Aroclors. A number of reports and a series of internal communications showed that Aroclors volatilized from the paint (a polymer) as soon as the paint was applied, even at ambient temperatures, and PCBs could persist in an indoor environment at concentrations above Dr. Drinker's recommended permissible limit. The tests

[29] Monsanto's publication promoting the use of PCBs in a nitrocellulose lacquer showed that Aroclors 1242, 1254, and 1262 volatilized from the lacquer from the start of the tests, with decreasing vaporization rates as the chlorine percentage increased (Aroclor 1242 is more volatile than Aroclor 1254, etc) (Jenkins, 1931). Additional information from this article is provided in Appendix B.

conducted during Aroclor production also showed that Aroclors could accumulate indoors at elevated levels even in areas remote from the manufacturing equipment.

Monsanto conducted two studies to evaluate PCB plasticizer loss and resulting air concentrations when surfaces were painted with Lustrex Latex paint containing Aroclor 1248, which was similar in composition to Aroclor 1254. In the first study, conducted at its Plastics Division facility in Springfield, Massachusetts, five of the air samples collected from the painted rooms with temperatures between 70 and 100 °F had Aroclor 1248 concentrations between 1 mg/cu. meter and 5 mg/cu. meter (MONS 061753, 12/31/1952). Monsanto noted that the high Aroclor levels were the "result of painting with an Aroclor-containing paint that could be attained under normal conditions with this type paint." (MONS 058945, 6/17/1953). Concerning selling Aroclor for use as a plasticizer in paint, Monsanto's Dr. Kelly stated that what he and others "were really worrying about" was an individual using an Aroclor containing paint, and then implicating a diagnosis of hepatitis to exposure because of the strong odor of the paint (MONS 095193, 2/12/1954).

In the second study, Monsanto had painted a room and a laboratory hood with Lustrex Latex Paint containing Aroclor 1248. The laboratory hood was heated to between 113 to 140 °F during the sampling period, and "[t]he [Aroclor 1248] concentration remained in the 1.0 – 2.0 mg. per cu. meter range over a period of about one month [the length of the study]." (DSW 147758, 3/15/54). Monsanto concluded, "In a heated room it appears that the concentration of Aroclor 1248 vapors may remain high for a long period of time." (DSW 147758, 3/15/54). The research report concluded that the Aroclor vapor concentration "was sufficiently high. . .to make the room unusable for about 3 days." The recommendations in Monsanto's final report stated, "Since the room painted with Lustrex Latex Paint containing Aroclor 1248 definitely has an odor of Aroclor for several days after painting, caution should be exercised in recommending Aroclor for this use." (DSW 147758, 3/15/54).

When reporting the results of the paint tests to MCL, Monsanto (U.S.) stated to MCL "As I'm sure you know, Aroclors cannot be considered non-toxic." Concerning the use of Aroclors as plasticizers in emulsion paints, Monsanto stated that "[w]e do not recommend that they be used in paints which might be applied in confined or unventilated areas, particularly if the paints might be used on heated surfaces." Monsanto was "worrying about" painters exposed to vapors "day in and day out" rather than "worrying about" occupants of the room "during or shortly after the paint has been applied." (MONS 095187, 9/1/1953).

Monsanto's sales division requested air testing at the Anniston Plant to determine the usual Aroclor concentrations to which workers were exposed (MONS058945, 6/17/1953). Twenty air samples were collected under varying conditions in the Anniston plant including during production of Aroclors 1242, 1254 and 1260. The Aroclor vapor concentrations ranged from 0.35 to 5.3 mg/cu. meter with the highest concentrations detected during production of Aroclors 1242 and 1254. Only one sample was below the "maximum tolerable concentrations." Furthermore, PCBs were detected in a remote location from the manufacturing operations above the maximum allowable concentration (MONS 058945, 6/17/1953).

From these tests, it is clear that Monsanto had information demonstrating that the three of the important characteristics of PCBs (toxicity, volatility and persistence) that make PCBs used in open use applications a lasting environmental problem. The tests showed that PCBs volatilized from the paint in both heated and unheated environments; the PCBs persisted in the air at elevated levels for a long time; and the elevated levels exceeded Drinker's worker exposure limit.

To "know a little better just what is the safe limit of Aroclor vapor" that workers are exposed to, Monsanto had hired the Medical Department at the Kettering Laboratory in Cincinnati to conduct animal experiments (MONS 095186, 3/15/1954). Dr. Treon at the Kettering Laboratory investigated toxic effects in animals from exposures to Aroclors 1242 and 1254 in part to "demonstrate the relationship between the extent of their chlorination and their toxicity." The studies showed that Aroclor 1254 was more toxic than Aroclor 1242 because Aroclor 1254 vapors of 1.5 mg/cu. meter caused positive signs of injury to test animals as compared to similar effects for Aroclor 1242 at 1.9 mg/cu. meter (MONS 088809, 6/22/1955; TOXSTUDIES0314, 6/28/1955, MONS 096370, 6/1956). The results were published in the scientific literature. In the article, Treon et al (1956) recommended tentatively the ACGIH threshold concentration of 1.0 mg/cu. meter of air for safe industrial practice. However, no studies were conducted to determine the concentrations of Aroclors 1242 and 1254 that showed no signs of injury to test animals.

Monsanto had retained the Southern Research Institute to determine the vapor pressures of Aroclors over the temperature range of 25 to 100°C (TOWOLDMON0048965, 2/4/1954 MONS 095188, 12/6/1955). SRI experimentally determined the vapor pressures of Aroclors 1242, 1248, and 1254 at four different temperatures (37.5, 54, 71, and 98°C) to obtain a relationship between temperature and vapor pressure in the desired temperature range (TOWOLDMON0048965, 2/4/1954). The SRI report yielded information that showed PCBs volatilized into air at room temperature. Using the information provided by SRI, MCL (Monsanto's British subsidiary) stated, "With reference to the impression generally given that cold Aroclors are safe. . .air saturated with cold Aroclor is at or above the maximum permissible concentration." (MONS 095188, 12/6/1955).

For example, the calculated saturated air concentration for Aroclor 1254 at 77°F was 1.5 mg/m^3. This value was 50% higher than the ACGIH's MAC of 1.0 mg/m^3 and equal to the PCB concentration reported by the Kettering Laboratory that showed liver damage in animals. Thus, unsafe saturation levels of PCBs were conceivable in enclosed spaces at room temperatures.[30] MCL's position was that future applications of Aroclors "must be governed" by the finding that prolonged exposure to Aroclor vapor at 1.5 mg/cu. meter "can produce damage to the liver and kidneys of test animals." (MONS 095215, 8/19/1955).

[30] In the mid-1950s, the Navy conducted experiments on animals exposed to air ***saturated*** with Pydraul 150 (25% Aroclor 1242) and found that liver damage was caused by skin adsorption without any sign of injury prior to autopsy. The Navy reported to Monsanto its position that "Pydraul 150 [was] just too toxic for use in a submarine." (DSW 148006, 6/7/1956; MONS 095639, 12/19/1956; MONS 095640, 1/21/1957; MONS 095645, 9/11/1957).

MCL also stated that "[i]n translating this finding to the human being it is the recognized practice to employ a safety factor of 10. . ."[31] For Aroclor 1254, MCL indicated the maximum safe level for the public would be below 0.15 mg/cu. meter, and this value would be applicable to all Aroclors since they were similar in chemical composition (MONS 095215, 8/19/1955).

MCL had also collected air samples after painting a room with latex paint containing Aroclor 1248 and reported concentrations were around 0.5 mg/cu. meter for a month. MCL pointed out that if this paint was used, a person would be exposed to a concentration far exceeding the 0.15 mg/cu. meters (based on the 1/10 safety factor). Therefore, MCL recommended following Monsanto (U.S) in "withdrawing our recommendation that Aroclors be used as a plasticizer in Lustrex Latex paints." The MCL memo noted that the use of Aroclors in ordinary paint still required examination because "[i]t now seems possible that a hazardous concentration could be attained in a room in which a large area is painted with Aroclor-containing paint." Furthermore, MCL noted that the rate of volatilization of PCBs from the paint was governed by the rate of migration within the dry paint. This meant that the PCBs could continue to escape into the air from the dry paint, but most likely at a slower rate than initially observed (MONS 095215 @095218, 11/26/1954; MONS 095215, 8/19/1955).

In conclusion, the various studies from the 1950s demonstrated Monsanto had information that PCBs were toxic; that Aroclor plasticizers would volatilize and continue to volatilize from the polymer product upon application of the product, even at ambient temperatures; and that the PCBs persisted in the air. Cumulatively, the findings from these experiments on toxicity, volatility and persistence of PCBs showed that PCBs as plasticizers would cause an environmental contamination problem.

Monsanto's stated position concerning sales of PCB-containing Aroclors as plasticizers in products sold for household uses in which users had the potential to be exposed to PCBs that escaped from those products was: "[w]e know Aroclors are toxic but the actual limit has not been precisely defined. . . .our main worry is what will happen if an individual develops any type of liver disease and gives a history of Aroclor exposure." (MONS 095196, 9/20/1955). In this same document, Monsanto stated if "it is distributed to householders where it can be used in almost any shape and form and we are never able to know how much of the concentration they are exposed to, we are much more strict." Monsanto also noted that no more toxicity testing was "justified" (MONS 095196, 9/20/1955). Nevertheless, as discussed in detail earlier in the report, Monsanto did sell its PCB-containing Aroclors for a number of household uses.

[31] In January 1954, an article in the quarterly bulletin of the Association of Food and Drug Officials of the United States was titled, 100-Fold Margin of Safety. The article stated that animals generally are "more resistant to toxic chemicals than man", and that "man is about 10 times as sensitive to poisons as the rat". Since humans cannot be used as experimental subjects, the toxicity of a substance must be based on studies in laboratory animals. The article also pointed out that a "safe dose" for chronic toxicity is "that dose just short of causing an observable effect." (Lehman et al, 1954). This safety factor is supported in the literature (Dourson et al, 1983). The maximum permissible limits set in the 1930s and 1940s did not take into account the 1/10 factor.

C. Toxicity, safe handling, vapor pressure, and stability information in Monsanto's promotional materials for Aroclors, plasticizers, and products containing Aroclors in the 1960s.

In February, 1961 the Plasticizer Sales Department published PLASTICIZER PATTER, for salesmen titled "End Uses for Aroclor Compounds", which contained information "useful to you in suggesting new uses or applications for the Aroclors and increasing your sales of these products." A significant number of uses listed were for PCB containing products that came in direct contact with humans or the environment. A partial list included: concrete and stucco paints, paper coatings, varnish for cedar and redwood, Christmas trees, icicles for Christmas trees, varnishes, floor wax, paperback novels, Reader's Digests, bookbinding adhesives, rug backings, flooring adhesives, sealing compounds for aluminum windows, curtain wall construction, building sealants, leather and shoe adhesives, epoxies, wall tile adhesives, paper base, wax paper coatings, hair brushes, carbonless carbon paper, insecticide carriers, printing inks, ceramic slurry, and water soluble soil-poison concentrate. These uses of PCB-containing Aroclors covered a wide variety of applications which had the potential for consumers to be exposed to PCBs (LEXOLDMON005375, 2/1961).

In the 1960s, several technical bulletins, catalogs and magazine advertisements were prepared by Monsanto suggesting a wide range of uses for its Aroclor compounds, including plasticizers. Some of the bulletins covered broad applications, such as "The Aroclor Compounds" catalog and others were tailored to specific markets, such as "Monsanto Modifiers for Thiokol Polysulfide Liquid Polymers." This bulletin discussed Monsanto's plasticizers compatible with polysulfide rubber, including PCB-containing Aroclors. The Aroclors were featured as the plasticizer for polysulfide joint sealants used in curtain-wall construction, a "rapidly growing" area that required "large quantities of permanently flexible, strongly adhering sealants." In the table of physical properties, unlike the other plasticizers, no vapor pressures were listed for the Aroclors (1221, 1242, 1254, 5460), even though Monsanto possessed this information since at least the early 1950s. Monsanto referred to its other technical bulletins for complete details on its modifiers with no mention of toxicity and hazard information (LEXOLDMON003993, 4/1962).

This bulletin as well as other bulletins and catalogs were entirely on applications with the potential for PCB exposure to humans and environment. The toxicity section appearing in most of the product literature was relatively unchanged from the 1940s bulletins. Despite the cumulative information revealed from the SRI studies, Monsanto's paint tests, MCL's paint test and the Mieg's article[32], Monsanto continued to inform potential customers that "[a]t ordinary temperatures the Aroclor chlorinated polyphenyls have not presented industrial toxicological problems. . . ." (TOWOLDMON0029987, 5/1960; MONS 080627, 1961). This statement did not warn customers of the potential for exposure to PCBs at ambient temperatures nor of any toxic effects from such exposure. In addition, there was no discussion that PCBs could persist in indoor or outdoor environments. The safe handling section was written for "Aroclor compounds" not products

[32] Internal memos by Monsanto and MCL both indicated the two companies were surprised by the results of the Miegs' publication (MONS 037711, 4/28/1954; MONS 095182, 6/17/1954). Specifically, MCL, upon only seeing an extract of this paper questioned Meigs' findings of worker exposure to 1/10th the permissible limit resulting in toxic effects (MONS 095182, 6/17/1954).

containing Aroclor compounds. Therefore, the context was clearly limited to industrial operations. Furthermore, the information in the bulletins on vapor pressure was misleading and reinforced the notion that PCBs were only volatile and toxic at elevated temperatures.

The 1960 technical bulletin written specifically for the plasticizer market "Aroclor Plasticizers PL-306"[33], in which all applications were open uses, provided tables and charts with volatility and vapor pressure information for some of the PCB-containing Aroclor products. This bulletin included a table of vaporization rates for various Aroclors and other competing plasticizers, with a summary statement that read "the vaporization rates of Aroclor plasticizers – especially the most widely used 1254 and 1260 – compare most favorably with the similar constants of other plasticizers selected specifically for these tests because of their low vaporization rates." (DSW352447, 12/1960). This information was misleading in that it appeared to place all the plasticizer compounds in the same category of toxicity, but no data on permissible limits and saturation concentrations were included.

Monsanto's 1961 news release for distribution to "chemical, plastics and rubber publications" described this new technical bulletin containing over 100 formulations for the use of Aroclors as plasticizers and extenders in a variety of resins. The beneficial characteristics of PCBs were noted, but there was no mention of toxicity, volatility or persistence in the environment (2018327144335627 – 3/14/61 News Release).

This 1960 bulletin also included a chart with Aroclor vapor pressures similar to that provided in the 1945 bulletin which only showed vapor pressure as a function of temperatures above 125°C (257°F). In the table of "Approximate Vapor Pressures," the vapor pressure of Aroclor 1254 was reported as 0.00006 mmHg ($6x10^{-5}$mmHg) at 100°F (37.8°C). This value was incorrectly and repeatedly under-reported in Monsanto's technical bulletins, which leads to incorrect assumptions about PCB concentrations indoors at ambient temperatures (TOWOLDMON0005563, 1960; DSW 352447, 12/1960; TOWOLDMON0024978, 10/31/1966).

The vapor pressure for Aroclor 1254 listed in the bulletins was an ***order of magnitude less*** than that determined by SRI for Monsanto. As discussed previously, SRI's research in 1955 resulted in the determination of vapor pressures for several of the PCB-containing Aroclors, including Aroclor 1254, which could be used to determine that the saturation concentration could reach or exceed the permissible limit at ambient temperatures. Using the lower, incorrect vapor pressure, the saturation concentration of Aroclor 1254 vapor in air at 100°F matched precisely the ACGIH's maximum allowable concentration of 1.0 mg/ cu. meter. But, when the correct vapor pressure based on the SRI data and equation is used, the resulting saturation concentration in air is actually 4.8 mg/m^3, ***almost 5 times higher than*** the ACGIH's maximum allowable concentration of 1.0 mg/ cu. meter.

[33] Technical Bulletin PL-306 was revised in 1966 and contained the same statements in the toxicity and safe handling section as the 1960 bulletin (TOWOLDMON0024978, 10/31/1966).

The saturation concentration at 100°F is ***nearly 10 times higher*** than the permissible limit of 0.5 mg/m^3as set by Drinker (1939).[34]

Monsanto included these permissible limits in the toxicity section of the technical bulletins. The language was "[t]he threshold limit values (maximum allowable concentration for an 8-hour working day) set by the American Conference of Government Hygienists are 1.0 milligram per cubic meter of air for the lower-chlorinated Aroclor compounds and 0.5 milligram per cubic meter of air for the more-highly-chlorinated compounds, such as Aroclor 1254."(DSW 352447, 12/1960; TOWOLDMON0024978, 10/31/1966). The incorrect and much lower vapor pressure reported for Aroclor 1254 at 100°F reinforced the statement that at "ordinary temperatures" PCBs did not present a toxicological problem to workers. In addition, Aroclors were described as being "virtually non-volatile" in many of Monsanto's technical bulletins without the context of toxicity at ambient temperatures (LEXOLDMON006711, 1964; DSW 352447, 12/1960; TOWOLDMON0005563, 1960; LEXOLDMON003993, 4/1962).

Furthermore, when Monsanto responded to customer requests and others on Aroclor toxicity in the workplace and for end users, it indicated the potential for injury was by the inhalation of vapors at elevated temperatures (MONS 097894, 2/8/1960; MONS 090360, 5/6/64; TOWOLDMON0054172, 2/7/1967). For example, Monsanto's Manager of Environmental Health, Elmer Wheeler, told Raytheon, "there is little vapor inhalation hazard when [Aroclors 1242 and 1254] are handled in a closed system or when handled at room temperature." (MONS 090360, 5/6/64). Also, Monsanto's Jack Garrett and Elmer Wheeler assisted the Industrial Hygiene and Clinical Toxicology Committee of I.M.A. with preparing the section on "chlorodiphenyls" (PCBs) for the "Hygienic Guide Series," dated Jan/Feb 1965. In the "Hazards and Their Recommended Control" section it stated, "[w]here chlorinated diphenyls are used at room temperatures, the hazard of inhalation is considered slight or absent." (MONS 076148, 1965).

Monsanto's promotions and advertisements were misleading as to the volatility of PCB-containing Aroclors. In one magazine, Monsanto advertised the Aroclors as "just about the most unreactive materials ever synthesized," and claimed "[t]hey stubbornly refuse to volatilize, oxidize, hydrolyze. . . disintegrate. . . ." (TOWOLDMON0047981, 1961). In another advertisement it stated, "They don't burn, evaporate, hydrolyze, or oxidize." (TOWOLDMON0047973, January 1961). And, in another trade magazine, Monsanto promoted PCB-containing Aroclors as being "virtually non-volatile" as well as inexpensive for waxes, sealants and mastics. Applications included floor waxes, furniture and shoe polishes, dental casting waxes; household uses which had the potential for direct human exposures to the PCB vapors (LEXOLDMON006711, 1964).[35] Gerald Miller, Chief Chemist for Monsanto in the 1960s, testified that the "inherent stability" of PCBs "was known probably" back in the 1930s and 1940s and agreed that it "was known early on" that stability meant they would "resist

[34] A comparison of the vapor pressures presented in Monsanto's product information with the vapor pressure calculated using SRI's equation is presented in Appendix D.

[35] A "Chemical Specialties Data Report" promoting "the values of Aroclor" when added to commercial waxes included formulations for household polish and car polish that had 30% Aroclor 1268 and 5% Aroclor 1242 (0509197, 11/1963).

degradation." (Miller Deposition, 2001 @ 22-23). Therefore, when Monsanto advertised the beneficial characteristics of PCBs used as plasticizers it had information that those properties are what made PCBs persistent in the environment. [36]

D. PCBs in open uses were released to and contaminated the environment.

As discussed earlier, Dr. Soren Jensen reported in 1966 that PCBs were detected in the wildlife in Sweden and in human hair, and in 1968 Dr. Risebrough reported finding PCBs in a number of fish and birds along the coasts of the western U.S. and Central America. After the ensuing media attention in the United States that PCBs had been found in the environment by Drs. Jensen and Risebrough, Monsanto formed internal committees, held company meetings and developed corporate strategy to handle the PCB problem. As discussed below, it directed its efforts at minimizing the negative publicity, maintaining sales of PCBs for open uses, developing its own analytical procedures, and investigating issues surrounding the presence of PCBs in the environment.

Monsanto's documents from the relevant time period indicate that the open uses of PCBs – those that directly interfaced with the environment – were significant sources of PCB contamination in the environment. Open uses included products formulated with PCB-containing Aroclor plasticizers. Monsanto retained Robert Metcalf, head of Zoology at University of Illinois to comment on the environmental contamination of PCBs being reported in the literature. He noted that "because of the apparent high stability of PCB, amounts entering the environment would be degraded very slowly and it seem[ed] possible that at least 10 million pounds annually may become environmental contaminants." Metcalf also informed Monsanto that the "the evidence regarding PCB effects on environmental quality [was] sufficiently substantial, widespread, and alarming to require immediate corrective action on the part of Monsanto." Metcalf recommended "[s]erious consideration of curtailing sales of PCB for uses such as plasticizers, adhesives and no carbon paper where waste is certain to enter environment" (*emphasis added*) (NEV 027182, 4/2/1969).

Dr. Widmark (Dr. Jensen's supervisor) met with Monsanto about the presence of PCBs in environmental samples and wanted Monsanto to restrict the sale to those closed system applications." Widmark indicated that marine paints were a source of PCB contamination in the aquatic environment (MONS 098104, 05/13/1969). Monsanto noted that "several scientists [were] alarmed about marine environmental contamination" by PCBs "which get into the atmosphere from processes involving plasticizer uses" and then end up the sea from "rain-out." (DSW 164905, 10/15/1969).

Monsanto stated in another internal document that "such paints containing Aroclors eventually end up in the drainage areas for the highways and provide a continuing source of PCB's to the limit of their solubilities." (DSW 164905, 10/15/1969). This statement demonstrates that Monsanto had

[36] Monsanto's publication promoting the use of PCBs in a nitrocellulose lacquer stated PCBs are "very stable chemically" (Jenkins, 1931).

information indicating that the mobility combined with low solubility of PCBs permitted continued contamination by a plasticizer application open to the environment.

Monsanto also identified PCB-based paints for water towers as sources of pollution (DSW 014612, 10/2/1969):

> "In the plasticizer use area, the Aroclors may be used in rubber based paints or surface coatings. The uses for these surface coatings include the interior walls of potable water supply storage tanks in some communities. . . .In spite of the low degree of solubility of the PCBs's in water, there are sentiments among the European scientists (and our PCB manufacturers) that such uses may be sources of pollution."

Monsanto had conducted experiments which showed PCBs were soluble in tap water at detectable levels (ppb range) and this low solubility resulted in long term dissolution of PCBs into water (MONS 097841, 6/10/1969 – handwritten notes dated 6/23/1969). In another experiment performed by Monsanto's chemist, metallic surfaces were coated with paint mixtures containing Aroclor 1254 and then submerged in water. After two weeks, detectable amounts of PCBs had accumulated in the surrounding water. This test indicated that PCBs could be extracted from coatings by water (PCB-ARCH0290075, 10/29/1969; MONS 068229, 3/1970). The results from both experiments were noteworthy because Monsanto's customers were formulating paint with PCB plasticizers for coating the inside of potable water towers and swimming pools, which would lead to direct contamination of the water. Monsanto's customers were also formulating coatings with PCB plasticizers for surfaces in direct contact with marine and fresh waters resulting in direct and persistent contamination of the water and sediments to which aquatic organisms were exposed.

In an internal discussion on the "possibility of contamination from plasticizer uses" Monsanto stated that "indirect contamination could occur from the eventual leaching of the Aroclors from the final disposal or ultimate end-point of any product containing them." (DSW 164905, 10/15/1969). Concerning the plasticizer market Monsanto stated that any decision on PCBs "affects a wide range of plastics and adhesives because the PCB serves as the plasticizer. A wide range of paints and coatings are affected." Plasticizers were also identified as sources of "indirect" contamination of the environment from "product contamination" including "coating for tank lining, printing inks and paper coatings, [and] certain adhesives." (MONS 035310, 11/10/1969).

An internal "PCB Presentation" was prepared for Monsanto's Corporate Development Committee *circa* late 1969 / early 1970. Its express purpose was to acquaint the Committee "with the PCB (Aroclor) pollution problem and to secure [the Committee's] guidance and approval on a recommended plan of action (MONS 058730, *circa* Dec 1969/Jan 1970). The Committee was informed that PCB-containing Aroclors sold as plasticizers could cause contamination from leaching and vaporization. For example, automotive sealants and construction and joint sealants were identified as possible PCB contamination sources due to "long-term leaching." (MONS 058730, *circa* Dec 1969/Jan 1970).

Monsanto also noted that the erosion of PCB-containing paints and sealants, also permitted the escape of PCBs into the environment. Through natural weathering and abrasion (natural and anthropogenic) of these materials, PCBs were released into the air and deposited on land or in water, or washed from the surface by rainwater and transported as runoff. For example, of the one million pounds per year of PCBs used in highway paints Monsanto "assume[d] that nearly all of this Aroclor winds up in the environment" through natural weathering and tire abrasion (MONS 030483, 9/5/1969).

Monsanto had also become aware of incidents of milk contaminated with PCBs in Ohio, Georgia and Florida. The contamination was traced back to cows consuming feed stored in silos painted with a surface coating containing Aroclor 1254. The PCB plasticizer in the paint had leached into the silage. It was estimated that over 40,000 silos had been coated with the PCB containing paint. Even after Aroclor 1254 was no longer available for surface coatings, Monsanto questioned whether silos were still being painted with previously purchased PCB containing paint (MONS 099541, 3/30/1970; MONS 087409, 7/28/1970; DSW 170864, 11/19/1970; DSW 325765, 10/29/1970).

E. Toxicity, safe handling, volatility and environmental hazards information in Monsanto's 1970 promotional materials for Aroclors as plasticizers did not alert customers that selling any products formulated with PCB plasticizers would result in contamination of the environment.

As late as March, 1970, despite the internal company discussions that PCB plasticizer uses had the potential to contaminate the environment, Monsanto published an updated version of its Technical Bulletin PL-306 for Aroclor Plasticizers (MONS 074441, 3/1970).[37] The "Toxicity and Safe Handling" section remained unchanged from prior versions. A new "Environmental Hazards" section was added to the revised bulletin with language cautioning customers to give "careful study to eliminate the possibility that PCB might reach the environment as a result of use in a given application." Monsanto only warned customers not to formulate products with PCBs for swimming pools, silos, other buildings storing food for humans or animals, and food wrapping and packaging, even though all plasticizer applications were previously identified by Monsanto as being sources of "indirect" contamination to the environment.

X. Monsanto promoted and sold PCBs for hydraulic fluids, lubricants and heat transfer fluids that were used in equipment prone to leaks and spills during operation and maintenance.

Monsanto promoted and sold PCB-containing industrial fluids starting in the early 1940s and continuing into the early 1970s despite having information that the equipment utilizing these fluids was prone to leaks and spills and the fluids would contaminate the environment. Monsanto created and sustained the PCB market for these applications without providing sufficient information to its customers on the persistent, bioaccumulative and toxic nature of PCBs in aquatic environments if the fluids reached surface waters via direct or indirect disposal, and without offering sufficient guidance on handling of spilled, leaked or waste fluids. Also, Monsanto compared Pydraul and Therminol to other

[37] In the "Recommended Action Plan" prepared for Monsanto's Corporate Development Committee, Monsanto stated it would introduce to the market replacement products for Aroclors as plasticizers on April 1, 1970.

hydraulic or heat transfer fluids (e.g. petroleum based), which implied they were not different with regard to their fate in the environment.

A. <u>Monsanto's promotional materials for Pydraul hydraulic fluids and lubricants did not include information on handling of these fluids to mitigate PCB discharges to the environment.</u>

Monsanto made and sold PCB-containing hydraulic fluids and lubricants under the trade name Pydraul.[38] Each one was a specific blend of Aroclor(s), phosphate esters and additives that gave each fluid required characteristics for industrial use. Table 5 contains a partial list of the some of the Pydrauls that Monsanto marketed to industry.

Table 5. Partial list of Monsanto's PCB-containing Pydrauls

Pydraul	Aroclor(s)
312	1242
F-9	1248
A-200	1242 + 1248
540	1248 + 1254
625	1254 + 1260
AC	1254

Monsanto's Technical Bulletins on its PCB-containing hydraulic fluids, first known as Aroclor 1248 and by 1951 as Pydraul, described their properties and uses and stated that "chlorinated biphenyl" was in "continuous satisfactory use" in die casting machines as early as 1939 (MONS078340,3/28/1949; PCB-ARCH0238233, 1950; WATER_PCB-00005488, 9/1968; TOWOLDMON0039160, no date; WATER_PCB-00006054, no date; TOWOLDMON0022105, no date). The text, <u>Introduction to Hydraulic Fluids</u>, written by Monsanto's Roger Hatton, identified Pydrauls F-9 and A-200 as PCB-containing fire-resistant hydraulic fluids used in die casting machines and in a variety of other types of hydraulic equipment (Hatton, 1962). This other equipment included hydraulic systems for mining operations (Pydraul MC), hydraulic lift operations for refineries and blast furnaces, and hydraulic operations with "vane, gear and piston pumps in high-speed machine tools." (EPRI, 1999; TOWOLDMON0027659, 1966).

Die casting is the process in which molten metal (a "shot") is injected under pressure into a reusable mold (called the "die") and cast into a particular shape. Die casting machines operate at high pressures to force the molten metal into the mold, and to maintain a tight clamp while the cast solidifies. The shot is fed into the die by a piston. Hydraulic fluid is required to pressurize and

[38] Monsanto also formulated and sold PCB containing lubricants for very specific purposes under other trade names as shown in Table 3 in Section IX.B. Santovac was used in vacuum pumps and Turbinol 153 was used in natural gas compressor systems. Turbinol 153 leakage from compressors during operation into transmission pipelines has resulted in soil and groundwater contamination in several regions of the United States.

lubricate the piston. By the 1920s, die casting was used for electrical, scientific and measuring instruments, automotive and airplane parts, and clerical machines, to name a few. The hydraulic fluid in die casting equipment is maintained under high pressure, therefore any ruptures or leaks in the hoses or gaskets can cause the fluid to spray out and come in contact with the nearby furnace and/or molten metal. Historical accounts of die casting facilities described fires and explosions caused by leaks and releases of mineral oil based hydraulic fluid (Everz 1957; Mitchell, 1964; Bailey 1962).

Monsanto promoted Aroclors for their fire resistance with the expectation that hydraulic hoses leaked, and when under pressure could release a considerable amount of fluid. The various technical bulletins that Monsanto distributed on the use of Aroclor 1248 and later Pydraul in hydraulic and other equipment were very similar. The bulletins contained information on the chemical and physical properties of the different formulations along with their primary uses. The bulletins clearly stated that line ruptures, system failures and leaks could occur spraying out hydraulic fluid under high pressure. From a fire safety issue this was not a concern since Pydraul was a fire-resistant fluid. With regard to handling, Monsanto informed customers that Pydraul was not a skin irritant or sensitizer, was not a vapor inhalation hazard at room temperature, and required no special handling. Monsanto only recommend the use of respiratory equipment if repeated and prolonged contact of Pydraul on heated surfaces occurred, due to vaporization and decomposition of Pydraul at elevated temperatures (MONS078340, 3/28/1949; TOWOLDMON0039160, *illegible date*; WATER_PCB-00005488, 9/1968).[39]

A 1957 article written by Monsanto's Frank Langenfeld compared the different types of fire-resistant phosphate ester-based hydraulic fluids for the die casting industry. In this article, the author did not distinguish toxicity of any of the phosphate ester-based fluids, including Pydraul, from the toxicity of petroleum-based fluids, the latter which he referred to as "fluids made by nature" (Langenfeld, 1957). This reinforced the false premise that PCB-containing Pydraul was not much different from mineral oil with regard to toxicity or environmental concerns; although Monsanto internally had information to the contrary. Although the article noted that phosphate ester-based hydraulic fluids could be reclaimed to reduce costs of new fluids, there was no mention of the importance of containing leaked or spilled hydraulic fluids (PCB-containing or otherwise) or preventing their entry into the environment.

In its Technical Bulletins Monsanto explained that capturing the Pydraul fluid lost through leaks and spills in containers or drip pans and then using on-site reclaiming equipment provided an economical savings advantage over other hydraulic fluids, but it did not mention any other incentive, such as preventing environmental pollution. In fact, the bulletins did not have a section on "waste disposal" or "waste handling". Guidance on how to switch hydraulic and other equipment from another fluid to Pydraul was included in the technical bulletins. While the bulletins

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[39] As discussed earlier in this report in the Section IXB, the Navy conducted experiments on animals exposed to air saturated with Pydraul 150 (25% Aroclor 1242) and reported to Monsanto that "Pydraul 150 [was] just too toxic for use in a submarine." (DSW 148006, 6/7/1956; MONS 095639, 12/19/1956; MONS 095640, 1/21/1957; MONS 095645, 9/11/1957).

recommended flushing the system with Pydraul before use, no information was given on how to handle the waste Pydraul drained from the system (MONS078340, 3/28/1949; TOWOLDMON0039160, *illegible date*; WATER_PCB-00005488, 9/1968).

B. Monsanto had information that die casting machines leaked significant quantities of hydraulic fluids during use.

Trade journals and other publications illustrated the significance of leaks from die casting machines. For example, a 1955 article appearing in *Applied Hydraulics* stated that die casting machines of that vintage leaked appreciable quantities of hydraulic oil. The author, J. R. Hemeon, a General Motors Hydraulic Equipment Engineer at the time of publication, reported leakage rates ranging from 10.2 to 46.4 gallons per 100 hours of operation. To provide some context, a leakage rate of 10 gallons per 100 hours of operation for a die casting machine running 40 hours per week equates to more than 200 gallons of hydraulic oil lost annually to leakage (Hemeon, 1955). A survey featured in a 1957 issue of *Applied Hydraulics* queried 700 men working on the design and maintenance of fluid power equipment used in die casting operations regarding their experiences with hydraulic fluid leakage (Applied Hydraulics, 1957). All of the men replied that hydraulic fluid leakage occurred either often or sometimes. When queried about how much hydraulic oil was lost annually to leakage, one large automotive firm estimated 400,000 gallons, or 60% of their yearly requirement. The *Applied Hydraulics* editors estimated yearly make-up requirements for many operations were 100% of the total oil in use. Eversz (1957) reported in *The Tool Engineer* on an operation with 14 die casting machines that lost, on average, 3½ barrels of hydraulic fluid per month. A sizable amount of fluid was lost during the changing of the dies themselves.

Monsanto's Richard Davis, was questioned in deposition about a 1957 document concerning a customer's employees that were injured from Pydraul sprayed from hose and piping failures. Davis testified that when "hydraulic hoses fail, break, get old, whatever is in the systems comes out", including Pydraul if it was the hydraulic fluid (WATER_PCB-SD0000043167 - Davis Dep, 11/28/1995; p.35).

Monsanto's Thomas Gossage (Director of Sales of the Functional Fluids Group in 1970) testified that certain Pydraul applications were not being used in closed systems. He stated: "At least, in the plants that I visited and the customers I visited, I saw applications where the fluid was being used in punching, stamping, forming metal parts where the hydraulic fluid was escaping from the equipment into sewer collection systems" (HARTOLDMON0025543, 8/6/1992 at p.32)

While it may have been reported in the literature that oily wastewater should not be discharged directly into surface water or sewers[40], the literature mostly described biodegradable oils that depleted the oxygen in the water during biological degradation, and not oils like PCBs with characteristics that resulted in their long-term presence and continued harm to aquatic environments. Monsanto had not disclosed the potential impact of PCBs in the aquatic environment to users of PCB-containing industrial fluids, nor had Monsanto disclosed the importance of preventing PCB-containing hydraulic fluid from entering the environment through plant effluent discharges or onsite disposal to the ground in technical bulletins, advertisements, other promotional materials and customer communications during more than three decades of customer use of such fluids.

This lack of disclosure was reflected in articles written by others describing the benefits of PCB-containing hydraulic fluids. A 1953 article in *Machinery* described the benefits of using Aroclor 1248 as a hydraulic fluid including its non-inflammability and noted that equipment leaks were more likely to occur than with mineral oil. Concerning safety, the article stated the fluid was not volatile "normally" but at "higher temperatures" vapors should be not inhaled. There were no precautions given on how to handle leaked Aroclor 1248 hydraulic fluid or to prevent entry into the environment (Machinery, 1953).

As late as 1968, an article described a steel mill's beneficial switch to Monsanto's Pydraul 312. For the furnace systems, the mill drained the old fluid and then flushed and refilled the systems with the Pydraul 312. No precautions were noted nor mention of how the mill handled the flushed Pydraul 312 (Iron Age, 1968).

Monsanto's Richard Davis admitted that while "safety and handling information always was provided to customers" he did not "recall early on" that any information was provided on procedures or guidelines specific to disposal, and he did not deem it be his responsibility to determine how customers were disposing of Pydraul (WATER_PCB-SD0000043167 - Davis Dep, 11/28/1995, pp.107-108). Davis testified that may have changed "somewhere in the . . . late '60s" when "Monsanto along with the rest of the world, became informed that there was (*sic*) some ecological issues to be examined." (WATER_PCB-SD0000043167 - Davis Dep, 11/28/1995, p.108).

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[40] In *Lubrication Engineering* Uhl (1954) stated, "[l]ubricating and hydraulic oils, if allowed to escape through leaky or faulty equipment, usually find their way into streams or sewers. They coat the surface of the water with a film of oil, thus shutting off oxygen needed by aquatic plants and animals. They also use up much of the oxygen dissolved in the water and thus hasten the early demise of all types of stream and pond life." He also noted that soluble or emulsible oil wastes have far-reaching deleterious effects when permitted to enter waterways. Therefore, "every effort must be made to control or eliminate them, regardless of cost." Furthermore, should they be allowed to enter public sewers, "they become an especial public problem in localities having sewage disposal facilities." In a later issue of *Lubrication Engineering* Dalbke et al (1965) reported that the presence of oil in waterways reduced the rate of oxygen diffusion from the atmosphere in addition to increasing the organic load, both of which deplete the dissolved oxygen supply available for aquatic life. In addition, these substances "are often toxic to much of the biota normally found in streams and upset the natural balance."

C. Monsanto's promotional material for Pydraul AC for air compressors did not include information on mitigating PCB-contaminated compressor fluid discharges to the environment.

Monsanto marketed Pydraul AC as a fire-resistant, low maintenance lubricant to customers operating air compressors (TOWOLDMON0035581, 1957). It was a 50 / 50 mixture (by weight) of Aroclor 1254 and phosphate ester. In the 1957 Pydraul AC bulletin, Monsanto publicized that Pydraul AC was "successfully lubricating hundreds of compressors of all types and sizes produced by all of the major compressor manufactures". With regard to safety, Monsanto stated that "rats survived a 6-hour exposure to an atmosphere saturated with Pydraul AC" indicating it was safe to use in air compressor systems (TOWOLDMON0035581, 1957). No other information on waste liquid handling was provided even though air compressors were not closed systems.

During operation of reciprocating air compressors for example, lubricant injected into the air system is later lost or discharged (Rollins, 1989; O'Neill, 1993). Air compressors contain cylindrical pistons to pressurize and compress air. A lubricant, such as Pydraul AC, is injected into the cylinder to coat the wall. As the piston slides up and down inside the cylinder the lubricant is entrained as an aerosol in the compressed air. The large droplets settle out and the smaller ones remain entrained in the air.

When water is removed from the compressed air, the oil droplets are removed as well. According to an industry publication, an air receiver collects enough oil and water to be drained "at least once a shift" (Gibbs, 1971). The water condensate and oil are collected in a sump or trap and discharged (Rollins, 1989; O'Neill, 1993). The very fine oil aerosols that "tend to stay in suspension in the gas in form of a fine mist" are commonly removed in a coalescing filter (O'Neill, 1993). A coalescing filter is a mesh-like filter that collects the droplets of lubricant as the air passes through. Aerosols collect on the filter forming larger droplets until the agglomerated droplets are pulled by gravity to a collection sump to be discharged (Gibbs, 1971; Rollins, 1989; O'Neill, 1993).

Monsanto had its own information that Pydraul AC escaped air compressors during normal and expected equipment usage. Richard Davis' testimony on air compressors demonstrated this internal information. Davis stated, "When air is compressed, water condenses out of it as a liquid and the small amount of lubricant would be included in that liquid and it is quite possible for the lubricant to appear in the water as tiny droplets therefore emulsified." (WATER_PCB-SD0000043167 - Davis Dep, 11/28/1995, p. 58). When further questioned about a customer's continued purchase of more Pydraul AC as a lubricant, Mr. Davis explained, "In the lubrication of an air compressor . . . lubricant is introduced in the cylinder of the compressor on a continuing basis and typically with any lubricant is discharged from the compressed air along with the condensed water." (WATER_PCB-SD0000043167 - Davis Dep, 11/28/1995, p.76). Despite having this information, Monsanto did not provide customers with information on handling this contaminated wastewater stream nor on the impact to the environment when this effluent was discharged.

Communications between Monsanto and its customers provided additional evidence that Monsanto had information on the loss and subsequent discharge of Pydraul AC into surface water and that Monsanto was not forthcoming on how the properties of PCBs made them different from petroleum- based compounds such that PCBs would persist and accumulate in aquatic ecosystems

for a long time. For example, in 1959 Air Products questioned Monsanto as to the "biological and botanical effect on fish life and plant life of Pydraul in concentrations of 1%-2% in water." (PCB-ARCH0622930, 11/5/1959). Dr. Kelly, Monsanto's Medical Director, replied that he had no experimental data but did not "believe that Pydraul would be any more toxic to fish" than petroleum or phosphate based hydraulic fluids since their toxicity was comparable in other manners. Kelly suggested fish tests could be run if necessary. He referred Air Products to its State Pollution Control Board to find out effluent limits for Pydraul AC discharged into streams as well as any procedures for running tests. He also noted that 1-2% or any organic material "will very probably kill fish." Since Pydraul was heavier than water it would settle to bottom and "furnish added protection from the standpoint of effect on fish." (MONS 091024, 9/30/1959).

Air Products replied that its original question about the "botanical effect of Pydraul AC on grass, shrubs, plant life, etc in concentrations of 1%-2%" was not answered. Monsanto's Industrial Hygienist, Jack Garrett, gave a similar reply to Air Products essentially characterizing all emulsified organic materials as behaving similarly. He explained that plants could be damaged from direct spraying of any emulsified organic material, and that untreated discharges of "any material containing suspended or emulsified organic substances" into a receiving stream "would be frowned upon" by state pollution control boards. Garrett noted that when Pydraul AC settled to the bottom of a stream it could cause damage to the food cycle: damaging bottom organisms would damage aquatic life feeding on them. Garrett would not answer Air Products directly as to whether its practices were acceptable without knowing more quantitative information about its discharges and the receiving stream. (PCB-ARCH0622929, 11/16/1959).

Monsanto's Garrett gave a very similar reply to another customer, Chicago Pneumatic Tool Company, upon its request for information about discharging Pydraul into receiving waters. He stated that Pydrauls would settle in streams and impact the aquatic life but that he didn't "expect" them to be toxic despite having no data. He also noted that small, accidental spills "would probably" have "no harmful effect" (MONS091044, 8/26/60). In neither instance did Monsanto offer to or recommend its customer conduct fish studies like the ones Garrett had described in the 1957 article about its acrylonitrile plant (discussed above in Section IX.B).

In 1969, Monsanto's PCBs (Aroclor 1254) were found in aquatic organisms in the Escambia River and Escambia Bay and the PCBs were associated with its own discharges of effluent contaminated with Pydraul AC (50% Aroclor 1254) into the river from its manufacturing plant in Pensacola, Florida (MONS 096470, 8/13/1969; MONS 097831, 10/13/1969; DSW 164905, 10/15/1969; Duke et al, 1970). Monsanto traced the source of the Aroclor 1254 to its use of air compressors at the plant and reported internally that "approximately two to six gallons a day of Pydraul AC was being lost" to its drains and eventually the river (MONS 036714, 1969). The water and lubricant from the air compressor system were being collected in a decanter that periodically overflowed causing the PCB-contaminated discharges (MONS 097083, 10/24/69). Concerning the PCB contamination in the Escambia River stemming from the Pydraul AC discharges, Monsanto internally stated:

"It may be a number of years, however, before Aroclor 1254 disappears from the river since bottom samples of mud have shown the presence of several hundred parts per billion of Aroclor. Evidence indicates that the more highly chlorinated PCB's including Aroclor 1254 are not subject to biodegradation" (MONS 036714, 1969).

D. Monsanto's promotional material for Therminol heat transfer fluids did not include information on handling of waste fluids to mitigate discharges to the environment.

Monsanto began selling Aroclors for heat transfer systems in the 1940s but did not introduce the tradename "Therminol" until 1962 (Monsanto Chemical Co, 1947; McArdle et al, 1948; C & E News, 8/1962). Sales of PCBs for heat transfer systems totaled over 20 million pounds just for the years 1962 through 1972 (DSW 532590).[41] Monsanto sold several different Therminol heat transfer fluids as shown in Table 6 below. Most of the fluids were just Aroclors marketed under a unique name (Davis, 1963; FUN008508, 12/1975).

Table 6. Monsanto's PCB-containing Therminol fluids.

Therminol	Aroclor
FR Lo Temp[(a)]	50% 1242
FR-O	80% 1242
FR-1	100% 1242
FR-2	100% 1248
FR-3	100% 1254

(a) Introduced in 1967 (PCB-ARCH0392789, 8/7/1967)

Monsanto promoted Therminol for its ability to provide heat transfer in a non-pressurized, forced circulation system. Its benefits also included providing heat up to 600 deg F, fire-resistance, cost savings, less maintenance and fluid make up, and ease of installation and operation (C & E News, 1962). A laundry list of industrial applications for Aroclor 1248 as a heat transfer fluid included chemical and metals processing, plastics and rubber processing, heating asphalt and "food processing, including potato chip and doughnut frying in vegetable oils" (MONS071541, 9/1956)[42]. Another of Monsanto's technical bulletins also listed "food cookers" and "potato chip fryers" as uses for Therminol (TOWOLDMON00055).

Monsanto's 1948 article on Aroclor 1248 (later marketed as Therminol FR-2) described the benefits of using the PCB fluid in heat transfer equipment – high boiling point, heat stability, fire resistance, and low vapor pressure – without noting any issues. The "Freedom from Toxicity Hazard" section noted that Aroclor 1248 vapors at elevated temperatures should not be inhaled and cited Drinker's

[41] Monsanto reported "zero" sales of PCBs for heat transfer equipment from 1957 – 1961. Sales data started in 1962 which appears to coincide with the introduction of the tradename Therminol.

[42] Monsanto recommended Therminol to a potential customer that sold doughnut fryers by highlighting the safety and fire-resistant aspects of synthetic heat transfer fluid over petroleum oil. Monsanto emphasized the many oil companies were using Therminol for heat transfer applications including Gulf Oil, Sun Oil, Phillips Petroleum, Sinclair, Shell Oil, and Standard Oil (PCB-ARCH0250620, 4/2/1965). None of these particular companies were using Therminol in food processing equipment.

recommended maximum permissible safe limit of 0.5 mg/cu meter for workers. Accidental leaks or spills were the only known losses and there was no guidance on no what to do with leaked or spilled heating fluid (McArdle et al, 1948). Although it was explained that fluid replacement was infrequent, the authors did not discuss how to handle and dispose of the Therminol removed from the equipment during maintenance.

In the 1959 Technical Bulletin Monsanto recommended using heat exchangers designed to avoid leaks and indicated that the Aroclor 1248 fluid could potentially last for seven years before replacement with the need for makeup fluid only following leaks or spills. Yet, no information was provided on how to handle or dispose of spilled or leaked fluid if it occurred nor how to handle or dispose of the "old" fluid when it needs to be replaced. The "Safety of Operation" section essentially indicated that Aroclor 1248 was safe at room temperature and the concern was mainly for workers to avoid prolonged exposure to vapors at elevated temperatures. Also, there was no mention of preventing waste fluid from entering the environment via plant effluent discharges to waterways or onsite disposal to the ground (MONS071541, 9/1956).

In 1966, Monsanto's sales and marketing group was involved in a project to promote the use of Therminol as a heat transfer fluid in food processing machinery such as doughnut, chip, fish, and meat fryers, as well as coffee bean roasters and other drying and baking equipment. A document entitled "Therminol Heat Transfer Food Industry Penetration" written by Stanley Shaw stated "[Monsanto's] objective is to be so knowledgeable concerning the Food Industry as to be most effective in exploiting that industry." Shaw also pointed out that "it is important, in fact imperative, that we develop methods of detecting contamination of cooking oils that may be indirectly heated with THERMINOL, as well as contamination of the food products themselves." He also stated that Monsanto "must <u>vividly</u> and specifically define the toxicological characteristics of THERMINOL. . . ." (MONS 037782, 10/13/1966).

The document listed 15 customers already purchasing Therminol for Food Processing applications including Campbell Soup Company and West Bend for its fry pans for home use, which Monsanto noted it initially helped develop.[43,44] There was some discussion on the lack of jurisdiction of the Food and Drug Administration (FDA) at that point in time, and awareness that FDA may get involved in the future due to "<u>possible contamination</u>". Monsanto again stated that it "should well document the ingestion characteristics of THERMINOL as well as other physiological effects. Simply, we must be able to state that so many grams or ounces of THERMINOL can be tolerated by an average <u>human</u> system with such and such an effect when accidently ingested. This may call for actual human taste panel tests with accompanying medical examination of individuals involved." The statements in this document clearly indicate there was the potential for heat transfer systems to leak, and that leaked Therminol could contaminate food for human consumption. In addition,

[43] In a 1964 memo to Campbell Soup Company promoting Therminol for their food processing equipment, Monsanto stated that companies were already using Therminol for potato chips and doughnuts (PCB-ARCH0250586, 11/11/1964).

[44] In a 1966 memo, Monsanto highlighted its success in selling Therminol into the food industry market. It stated: "Sales of the West Bend Therminol frypan have now penetrated 270,000 homes (a quarter of a million pounds of Therminol)." (STLCOPCB4096628, 10/24/1966).

Monsanto had sold its PCB-containing fluids for use in household products (MONS 037782, 10/13/1966; *emphasis in original*).

Monsanto's January 1969 Statement on "Toxicity and Safe Handling of Therminol FR-1, FR-2 and FR-3" focused on worker exposure to Therminol liquids and vapors evolved at elevated temperatures. It had one statement about ingestion that read, "[o]n the basis of animal toxicity studies, the Terminols (*sic*) may be considered only slightly toxic from the standpoint of accidental ingestion. . . ." (MONS065303, 1/23/1969). Despite the information that Monsanto had on the chemical and physical properties that caused PCBs to be an environmental contaminant, and the information it had concerning PCBs being found in the environment, Monsanto offered no warnings or guidance on how to handle Therminol leaks or spills to prevent entry into the environment, beyond precautions for worker safety.

Finally, a later Technical Bulletin on Therminol did address the environment. In the "Safe handling and disposal section" it read (TOWOLDMON0023545, no date):

> "While it is believed that Therminol heat transfer fluids pose no serious problems with respect to the environment, as a concerned supplier to industry Monsanto urges the user to maintain a tight system, to correct leakage promptly and to exercise care in the handling and disposal of this and all other such products. A tight maintenance program not only protects the environment, but keeps employees comfortable. . . ."

This statement was insufficient notice to customers to keep Therminol out of the environment because PCBs were persistent, bioaccumulative and toxic to aquatic life; information that Monsanto had with regard to PCBs. For example, Monsanto internally documented 860 heat exchanger systems using around 800,000 gallons of Therminol and noted that in "many cases, the units are small and we are not convinced that the operators have either the desire or the capability to operate a leak free system." (PCB-ARCH0729791, 8/16/1971).

E. <u>The escape of PCBs from semi-closed systems (e.g. hydraulic and heat transfer equipment, air compressors) during normal usage and maintenance caused contamination of the environment.</u>

Monsanto had experience with Therminol leaking into its products from its own heat transfer system in its PCT manufacturing process. While discussing PCT manufacturing and the possible presence of PCBs in the compounds, Paton explained that "therminol [was] leaking into the terphenyl chlorinator" and he requested that someone to "determine steps that can be taken to prevent leakage of therminol into chlorinator cooling lines plus fail-safe detection system." (TOWOLDMON0059220, 11/27/1968).

In response to Dr. Richard's question "are we preparing ourselves and customers to minimize or prevent process, stream and air pollution?" (PCB-ARCH073447, 5/20/1968), Richard Davis wrote (PCB-ARCH0289839, 5/23/1968):

> "The major entry of Aroclor into sewers and streams from industrial fluids applications is in industrial hydraulics. We are prepared to design, install and start up effective fluid recovery

> systems which remove Pydraul from plant effluent. . . . A few customers use the system as an economic measure. If and when more customers are pressed to keep Pydraul out of streams due to government legislation, we are prepared to act by referring them to Findett [Service Co.] or serving as prime contractor, subcontracting to Findett."

When asked about any other actions Monsanto took to prepare customers to minimize or prevent PCB pollution, Richard Davis testified that Monsanto "did things to minimize losses of fluids for economic purposes. . .because the ecological issue had not come to my attention." (WATER_PCB-SD0000043167 – Davis Dep, 11/28/1995, pp.181-183).

When asked why Monsanto would wait until customers were pressured by legislation, Davis testified that it was a "matter of filling a need. The customer sees no need, has no need, we're not going to press things on that they don't want. The economic loss is their loss and they balance the recovery costs against replacement fluid loss. As far as the ecological issue, I state again it was just surfacing as far as I know at this time." (WATER_PCB-SD0000043167 – Davis Dep, 11/28/1995, pp.181-183).

When further pressed about why Monsanto did not directly notify customers at that time (mid-1968), Davis testified that Monsanto wasn't assured there was an environmental problem with PCBs and therefore it shouldn't tell customers that they should do something (WATER_PCB-SD0000043167 – Davis Dep, 11/28/1995, pp.181-183).

Monsanto already had information on Jensen's findings along with its own information that hydraulic systems do leak and enter sewers and streams, yet Monsanto did not directly notify its Pydraul customers to prevent entry of PCBs into the environment until the early 1970s. Monsanto had an agreement in place with Findett Service Co. (Findett) for reclaiming used heat transfer fluid in 1963, but did not have a similar agreement in place for hydraulic fluid at that time. (PCB-ARCH0059258 1/8/1963; agreement signed 2/19/1963)[45]. Also, Monsanto's September 1968 Pydraul Bulletin, did not discuss reclaiming fluid with Findett, made no mention of any ecological issues with PCBs in the environment, and offered no guidance on properly handling, containing and disposing of spilled, leaked or waste hydraulic fluids to prevent entry into sewers or streams.

In early 1969, Monsanto internally noted that it needed to minimize PCB losses for large hydraulic users, while recognizing that it "can't easily control hydraulic fluid losses in small plants." (MONS 096509, 3/6/1969). In addition, while discussing Aroclor disposal options for off-grade industrial fluids, Richard noted, "We don't have any plan to collect and destroy contaminated Pydraul hydraulic fluid or lubricant. We have an appreciable volume of Aroclor in this use, something like 7 [million pounds]" (PCB-ARCH0059511, *circa* August 1969).

[45] For example, upon request Monsanto informed General Mills that reclamation of "contaminated or degraded THERMINOL" was provided by Findett Service Company in St. Louis, Missouri. Monsanto indicated that its customers worked directly with Findett, which minimized time and cost. Also, Monsanto noted that "many" of its customers found Findett's service "to be excellent and . . .the economics justifiable." (PCB-ARCH0250735, 11/2/1964).

In another internal memo titled "Defense of Aroclor – [Functional] Fluids, Monsanto presented a chart of functional fluids and "possible pollution by customers plant operation", which showed that hydraulic fluids, air compressor fluids, and heat transfer fluids all had a "yes, leakage external" (DSW 014256, 9/9/1969). With regard to hydraulic leakage and air compressor fluids, Monsanto indicated that the "product could be caught at machines but will take a lot of clean-up work with customers."

Concerning "sources of contamination" Monsanto noted that "Fluids are probably the most open sources of pollution because of their mobility. . . . Electrical customers have in the past sewered their wastes. . . .Heat transfer customers have sewered their objectionable and their spilled material." Industrial "fluids have generally been sprayed into drains, washed down sewers and generally regarded as very harmless." (MONS 035372, 1969). Another internal report on "PCB Pollution" also noted that "Industrial fluids [are]. . .very difficult, if not impossible to control." (MONS 034081, 10/29/1969).

In an internal report titled "Reclamation Strategy", Monsanto evaluated the benefits of entering into the reclamation market for hydraulic fluids while again noting that hydraulic systems leak and the fluids contaminate the environment. The author of the report stated (PCB-ARCH0031866, *circa* 1972):

> "By nature of most die-casting and foundry operations, large quantities of hydraulic fluid has gone directly into the plant effluent through system leakage, thereby causing both an economic loss and an environmental problem."

The author further explained the problem with customers continuing to use PCB-containing Pydraul in their systems (PCB-ARCH0031866, *circa* 1972):

> "There are presently 4.5 [million] gallons of PCB /PCT pydraul in customer's machines and collection systems. Without reclamation and only system "top -up" with a [phosphate ester] fluid, most of the existing fluids will have leaked into the environment within two (2) years. Reclamation provides the user with a fluid he can continue to use and at the same time, keep the fluid out of the environment."

As discussed below in Section XI, "top-up" or "top-off" is exactly what Monsanto told its employees to tell customers to prevent them from returning any PCB-containing Pyrdraul.

The author also pointed out (PCB-ARCH0031866, *circa* 1972):

> "Most die-casting and foundry hydraulic systems are prone to leakage of the fluid into the plant effluent and into the watershed. In addition, there are system failures and spills which can contribute substantially to the total fluid lost. Practically all new fluid sales to a user is to 'make-up' for that portion of fluid that leaks from the system."

The report listed a number of benefits for using Findett as Monsanto's sole reclamation company, which included Findett having "worked with Monsanto products for 9 years." As stated above, Findett began reclaiming Therminol for Monsanto's heat transfer fluids customers since 1963. The

report ended with a date of 11/1/1972 for Monsanto to evaluate the program and decide if it would expand or terminate it (PCB-ARCH0031866, *circa* 1972). Prior to the date of this report, Monsanto had entered into a non-disclosure agreement with Findett to share confidential information about its industrial fluids in order "to assist Findett in successfully reclaiming" Monsanto's industrial fluids (PCB-ARCH0731030, 8/19/1971).

Hydraulic fluids were discussed during a 1971 presentation by Monsanto's spokesperson William Papageorge to a selective group of transformer and capacitor manufacturing companies with a mutual interest in the continued use of PCB-containing dielectric fluids. He stated that hydraulic fluids were used in applications that were not "maintained to a degree where everything is leakproof. Many of these connections leak, hoses burst, and the tendency is to keep producing by adding more fluid. So it is conceivable that many of these hydraulic fluids ended up in the sewer. I do not intend to criticize the customers of our products. From the knowledge that we had at that time of the material the practice was considered acceptable" (ADM 007693, 9/14/71). As discussed above, Monsanto's customers were not informed by Monsanto on the need to prevent entry of leaked PCB-containing Pydrauls into the environment until the early 1970s. In addition, Monsanto's statement about its knowledge to this group of companies was misleading in that Monsanto had collected information over decades that PCBs were toxic, mobile, persistent and bioaccumulative.

Even after Monsanto ceased sales of PCB-based Pydrauls, PCB-contaminated discharges continued for a number of years. According to a talk presented at the National Conference on Polychlorinated Biphenyls held November 19-21, 1975 titled "Polychlorinated Biphenyl Usage and Sources of Loss to the Environment in Michigan" PCBs remained in industrial systems even after repeated flushings. The article specifically identified hydraulic systems as a major source of PCB contamination because "residues in discharge lines combined with loss of contaminated replacement fluids appear to result in continued low-level discharges." (Hesse, 1976).[46] Stanton Kleinert, Wisconsin Department of Natural Resources (WDNR) Surveillance Chief, summarized the recent WDNR investigations to identify PCB sources and levels in Wisconsin's waters at the same conference. He reported that cooling water from several aluminum foundries contained PCBs and that a "close investigation revealed the common source [from the foundries] to be leaking hydraulic fluids containing PCBs, which were used in die cast machines." (Kleinert, 1976).[47]

When Papageorge discussed PCB-containing heat transfer fluids in his presentation to the transformer and capacitor manufacturing companies, he stated: "We thought at one time that these were adaptable to close control and proper maintenance where we could logically call them closed systems. Some recent evidence indicated that we were wrong. . . ." (ADM 007693, 9/14/71). Papageorge cited a recent incident in which the industrial use of Therminol heat transfer fluid created a chicken, egg, and fishmeal PCB contamination problem. This statement was not accurate because Monsanto already had sufficient information from past years showing that heat transfer systems could leak. Monsanto already had information from three years prior about the 1968

[46] Conference Proceedings of the National Conference on Polychlorinated Biphenyls, 1975.

[47] Ibid at pp. 124-126.

"Yusho" Japan incident and the 1968 peanut oil incident in Holland in which heat transfer systems leaked, causing PCB contamination of the heating oil and ultimately contamination of food for human consumption. [48,49]

Monsanto's Board of Directors approved the termination of PCB fluids for use in heat transfer applications at its December 9, 1971 meeting. Sales had already been discontinued for "new heat transfer fluid systems several months ago."

XI. Monsanto continued promoting and selling PCBs despite scientific reports of PCB contamination of the environment.

Monsanto continued its sales of PCBs for open use and semi-closed applications for several years despite having been informed of the widespread presence of PCBs in the environment. Monsanto delayed providing sufficient information to its employees, customers, end-users, governmental and regulatory agencies, and the public, while continuing to sell PCBs for applications that had led to environmental contamination, and Monsanto prevented timely inquiries into past PCB-containing uses and legacy PCB contamination.

A. Monsanto's approach on how to handle the "adverse publicity" of PCBs and on how to continue selling its PCB-containing Aroclor products

After being informed of the findings of PCBs as environmental contaminants per Drs. Jensen and Risebrough, Monsanto discussed the continued sales of its Aroclor products. In an internal memo, Monsanto reviewed the "adverse publicity in Europe," and "[d]ue to the importance of the Aroclor products to the Organic Division" a "plan of action" was proposed to "make sure our Aroclor business is not affected by this evil publicity." (MONS 097089, 2/13/1967). To further sales of its Aroclor business, Monsanto's Board of Directors unanimously voted in a favor of an appropriation request of $2.9 million to expand its Aroclor production facilities at its two manufacturing plants to improve quality and capacity (DSW 013006, 11/22/1967). And, at a 1968 Monsanto Corporate Development Committee meeting that centered on Aroclors, one of the issues discussed was "how to significantly increase the sales growth while maintaining the domestic supply position and profitability." (TOWOLDMON0001287, 4/22/1968).

In an internal document titled "Future Plans for Aroclor Plasticizers" Monsanto outlined its plan for PCB-containing Aroclors "if the worst were to happen and [it] began to lose sales rapidly as [its] customers take the easy way out and discontinue using them." With regard to communications on

[48] In 1968, over 1000 people in the western part of Japan had reported illnesses requiring medical treatment due to consuming rice oil contaminated with a Japanese brand of a PCB-containing heat transfer fluid, similar to Therminol FR-2. The rice oil had become contaminated when the PCB-containing heat transfer fluid leaked out of the heating equipment and into the oil (MAE 053222, 2/14/1969; Kuratsune et al, 1971). Internal memos show Monsanto became aware of the "Yusho Incident" in early 1969 (MONS 090070, 1/23/1969; MAE 053222, 2/14/1969). In 1971, the Japanese government placed a total ban on PCB usage in the country by September 1973 (PCB-ARCH0517975, 9/1968).

[49] Santotherm FR-1 (MCL's name for Therminol FR-1: 100% Aroclor 1242) had contaminated peanut oil used for cooking potato crisps at a facility in Holland (MONS 097449, 2/15/1968; MONS 097448, 3/7/1968). "Dr. Keller's group is cognizant of the problem we have with chlorinated biphenyl contamination in the food processing industry" (MONS 097447, 3/25/1968).

Aroclor publicity, this plan recommended that Monsanto "not bring this publicity to the attention of our Aroclor customers" including the sealants, coatings and hot melt adhesives customers. Monsanto stated, "[t]he adverse publicity on Aroclors may have little impact or it may be very damaging, particularly if customers decide to play it safe and formulate around Aroclors." (DSW 593169, 3/12/1969). According to Monsanto's sales figures 1970 was its largest year for sales of PCBs for plasticizer applications (see Figure 5 in Section VII.B).

Monsanto also stated that it would "fight" the analytical procedures used by Drs. Jensen and Risebrough before doing much else. For example, shortly after being informed of Dr. Jensen's work, Monsanto stated in an internal memo that it "should fight the battle of the analytical method first before we get too involved with toxicology." (Mons 097694, 2/27/1967). Similarly, in response to Dr. Risebrough's findings, Monsanto directed Dr. Scott Tucker, a staff analytical chemist, to assist in "fighting the analytical battle. [He] is going to scrutinize the analytical aspects and particularly the validity of some of the assumptions made by the author" (MONS 097123, 10/21/1968). A few months later, in an internal memo titled "Aroclor Wildlife Accusations", Monsanto summarized its position in dealing with the information contained in Dr. Risebrough's publication:

> "It will be still more difficult to control other end uses such as cutting oils, adhesives, plastics and NCR paper. In these applications, exposure to consumers is greater and the disposal problem becomes complex. If chlorinated biphenyl is shown to have some long term enzyme or hormone activity in the ppm range, the applications with consumer exposure would cause difficulty. . . .Here there is no question of identification. Either his position is attacked and discounted or we will eventually have to withdraw product from end uses which have exposure problems" (MONS 096509, 3/6/69).

Monsanto's position as to how the news of PCBs being found in the environment could affect its fluids customers and ultimate consumers was: "One of the unique features of PCB's is their fire resistance. Here the basic decision is whether to risk lives due to fire or risk extinction of, some species of birds. In this case the PCB would probably be accepted as a necessary pollutant and tolerated under controlled conditions." (MONS 035372, 1969).

At a meeting among PCB manufacturers in the U.S. (Monsanto) and Europe (Bayer, Caffaro, and Prodelec), to address the global dimensions of PCB contamination of the environment, it was agreed that the PCB problem was international and in order for PCB sales to continue, the companies "must prove that they are not responsible." To achieve this, they needed to "stick together, prove their case, educate authorities, the universities and the public." A review of the environmental issues was presented by Monsanto. With regard to the principle sources of marine pollution, the following was noted (PCB-ARCH-EXT0013623, 2/9/1970):

1. Direct effluent to sewers, drains and streams
2. Accidental spillage contaminating surface drains
3. Atmospheric pollution and fall-out
4. Contamination of streams and rivers through careless disposal of dry waste.

Monsanto also informed the group that “it has been estimated by a U.S. customer that about 2 million lbs of PCB is thrown away per year. Of this ± 1 ½ [million] lbs are contaminating drain waters.”

B. Monsanto released misleading information to the public and government agencies about PCBs as an environmental contaminant while continuing to promote and sell its PCB-containing Aroclor products.

The U.S. media informed the public of Dr. Risebrough’s research findings on PCBs. The San Francisco Chronicle published an article with the headline, “A Menacing New Pollutant” in February 1969 (Perlman, 1969) and the LA times and a local TV station had news coverage (MONS 097499, 3/3/1969). In response to this publicity highlighting PCBs as an environmental contaminant, Monsanto released misleading information to the public and government agencies about PCBs. For example, Monsanto issued a press release with several arguments to refute the claims made by Dr. Risebrough and the media about the widespread use of PCBs and its ubiquity in the environment, including questioning whether PCBs was the chemical that was even detected, even though Monsanto was already informed of the soundness of Dr. Jensen’s work by Shell Chemicals in February, 1967 (MONS 097499, 3/3/1969):

- Monsanto stated that PCBs were not “used in tires, house paint, household products, epoxy resins or major vinyl plastics,” but its own promotional literature had recommended PCB-containing Aroclors as plasticizers to be incorporated into a number of household products.
- Monsanto stated that PCBs as plasticizers were “incorporated into the polymer as an integral part of the solid material. This applies whether the polymer is used as an adhesive, an elastomer (sealant) or a surface coating.” However, as discussed previously, Monsanto’s internal company documents and the scientific literature on polymer science showed that PCBs as plasticizers escaped from the polymer products and into the environment.
- Concerning toxicity, Monsanto stated “PCBs are not hazardous when properly handled and used.” However, Monsanto did not define proper handling for consumer products containing PCBs as the plasticizer in any of its promotional materials nor in the press release. Similarly, Monsanto did not provide guidance of proper handling of industrial fluids to prevent entry into the environment.
- Monsanto stated the PCB containing fluids were “for heat-transfer applications where the PCB fluid functions in a closed system.” However, by this time Monsanto already had information that heat exchangers leaked during operation and fluid leaked or spilled during maintenance.
- With regard to its presence in the environment, Monsanto stated that PCBs “are not sprayed or dusted on crops, woodlands, or any other areas, as are pesticides.” The press statement concluded with “[t]he source of the marine life residue identified as PCB is not

yet known." (MONS 097499, 3/3/1969). However, Monsanto's internal documents showed that it sold PCBs for use as insecticide carriers / pesticide extenders.[50]

Monsanto provided similar misleading statements in response to public and government inquiries. It erroneously claimed (MONS 088331, 3/14/1969; GPFOX00045446, 7/15/69; NCR-FOX-0575899, 7/23/1969):

- PCBs were used in closed systems like transformers and capacitors; their use was restricted and they were not "widely used" in household products;
- The use of PCBs as plasticizers in product such as adhesives, coatings, and specialized elastomers were an integral part of the material and could not be washed away;
- Risebrough may have misidentified PCBs as the chemical present in the environment;
- PCBs were not "broadcast in the same fashion" as chlorinated pesticides (e.g. DDT);
- PCBs were not hazardous or "seriously" toxic if handled properly and only to avoid exposures at elevated temperatures; and;
- Monsanto stated that PCBs presented "little vapor inhalation hazard at ambient temperatures."

Monsanto's Papageorge who was managing the PCB environmental issues from a corporate perspective, gave a speech titled, "Monsanto's PCB Program," to the 1971 American National Standards Institute Committee meeting. Highlights from his talk outlined Monsanto's position on the PCB situation (ADM 007693, 9/14/1971):

- Monsanto referred to PCBs in household products, as "so small, we Monsanto were not aware of [them]."[51]
- Monsanto stated the popular press was responsible for the unsubstantiated claim of PCBs being referred to as "hazardous poisons."

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[50] As discussed above in Section IX.A., Monsanto promoted and sold PCBs and PCTs to pesticide producers (over 147,000 pounds between 1953 and 3/1956) for use as an extender (e.g. Lindane) starting in the 1950s. The pesticides (with PCBs as the extender) had the potential for broadcast use (MONS 092048, 8/30/1957; TOWOLDMON0029987, 5/1960; DSW352447, 12/1960; TOWOLDMON0043718, 3/1961; MON-MT-003143, 4/13/1970). However, Monsanto did not provide this information on sales and usage when it wrote to Mr. Robert Z Rollins, Chief, California Department of Agriculture that, "To the best of our knowledge, Aroclors are not used as solvents in pesticide formulations." (TOWOLDMON0003805 @3810, 4/10/1969). One year later, in a confidential memo, Monsanto wrote, "Effective immediately, Monsanto will discontinue the sale of PCBs to any customer using or intending to use PCB as an insecticide/pesticide carrier." Several customers were listed with the advice to call and inform them of the decision, and to avoid adding new customers (MONS 099535, 4/23/1970).

[51] As noted above, Monsanto helped West Bend develop Therminol-containing frypans for home use and 270,000 had been sold as of 1966 (MONS 037782, 10/13/1966; STLCOPCB4096628, 10/24/1966).

- Monsanto spoke about the ubiquitous nature of PCBs: "A thought we must all keep in mind, too, is that we've got to live with the PCB's we introduced into the environment for the past 40 years. They have not disappeared overnight; they will not disappear overnight."

In a July 16,1970 News Release, Monsanto described its decision to discontinue sales of PCBs into "open systems." Monsanto also stated that it had reformulated some Pydraul without PCBs and would continue with alternate formulations since hydraulic systems could not be strictly controlled (MONS057292, 7/16/1970). However, Monsanto continued to market and sell PCB-containing Pydraul. In fact, it sold more than 1.5 million pounds of PCB-containing hydraulic fluids and lubricants in 1971 (DSW 532590).

C. <u>Monsanto disseminated minimal information to its customers and salesmen on the problems with PCBs while continuing to promote and sell its PCB-containing Aroclor products.</u>

Despite the accumulation of scientific data showing the dangers of bioaccumulation and bio-magnification of PCBs through the food chain of predatory birds, the Organics Division "has a concerted effort underway to protect continued sales and uses." (MONS 036714, 1969). Monsanto formed a PCB Committee to make initial recommendations on how to proceed given the "negative publicity" on PCB contamination of the environment. Handwritten notes from the PCB Committee meeting stated (MON-MT 003311, 8/25/1969):

> "Subject is snowballing…Where do we go from here…Alternatives: 1.) Go out of Business 2.) Sell (The Hell out of) them as long as we can and do nothing else"

A Monsanto document titled "The death of Aroclor" illustrated the company's decision-making process with regard to its two alternatives cited above. On a graph showing sales versus time, the "Let it die" option resulted in a rapid decrease in sales in the shortest amount time whereas the "delay the death" option resulted in a slow decrease in sales over time until sales reached a plateau (MONS 045497, no date). Monsanto then formed a corporate Aroclor "Ad Hoc Committee" to figure out future steps. It convened the first meeting on September 5, 1969. The three objectives of the Committee were to: (MONS 030483, 9/5/1969):

> "1. Permit continued sales and profits of Aroclors and Terphenyls.
>
> 2. Permit continued development of uses and sales.
>
> 3. Protect image of Organic Division and of the Corporation."

Specifically concerning its Aroclor fluids sales, Monsanto outlined its policies, problems and action items in an internal memo titled "Defense of Aroclor – [Functional] Fluids." Under "General Policy" Monsanto stated it would "[m]ake the Gov't., States and Universities prove their case." And it would [c]omply and work with public officials since "[a]dverse publicity and competition are the real weapons." (DSW 014256, 9/9/1969). More explicitly, Monsanto stated it was up to the government to prove that Aroclors were "bioharmful", while Monsanto proved they were "bioharmless." In addition to trying to find a "Safe" toxic level for man, mammals and fish through experiments on

rats, chickens and fish, it would "question evidence against us. Question shrimp toxicology especially other toxic chemicals. If Aroclor bad, others must be worse." (DSW 014256, 9/9/1969).

In the same memo, Monsanto stated: "We can't defend vs everything. Some animals or fish or insects will be harmed. Aroclor degradation rate will be slow. Tough to defend against. Higher chlorination compounds will be worse [than] lower chlorine compounds. Therefore we have to restrict uses and clean-up as much as we can, starting immediately." (DSW 014256, 9/9/1969)

Concerning hydraulic fluids, Monsanto noted that "shrimp experiments, West Florida State to be "aired" sometime soon; next few months. This will lead to bad publicity and competitive action vs all Pydrauls. We will have to try to confine to Aroclor 1254 and Aroclor 1260." (DSW 014256, 9/9/1969). Monsanto recognized that it needed to keep the focus on Aroclors 1254 and 1260 by finding replacements for the Pydrauls containing these particular Aroclors (e.g. Pydraul AC). Aroclor 1242 was considered not to be a good substitute because it too would be reported as "a significant water pollutant thus seriously endangering a market which so far has not been questioned." (MONS 071163, 9/25/1969). Monsanto recognized that customers utilizing hydraulic fluids and lubricants released PCBs into the environment and it did not want to negatively impact the sales of Aroclor 1242 for other applications.

Following a second meeting of the Aroclor "Ad Hoc Committee", a number of alternatives were presented for consideration to mitigate the negative publicity of PCBs, given that PCBs were being identified as contaminants of the environment, the chemical stability (persistence) of the higher chlorinated Aroclors (1254, 1260) and the existence of significant toxicological effects in wildlife species. The alternatives included (DSW 164905, 10/15/1969):

> "1) Say and do nothing – making the governmental agencies prove their case…
>
> 2) Take action to create a smoke screen hoping to delay any restrictive action by governmental agencies.
>
> 3) Immediately discontinue manufacture and sale of Aroclors 1254 and 1260.
>
> 4) Discontinue manufacture and sale of all polychlorinated biphenyls.
>
> 5) Respond responsibly admitting that there is growing evidence of environmental contamination by the higher chlorinated biphenyls and take action to resolve the problem…such a course of action would postpone precipitous action by governmental agencies for a few months and then limit any restrictions to Aroclors 1254 and 1260."

Soon thereafter, Monsanto issued its PCB Environmental Pollution Abatement Plan based on the Ad Hoc Committee's work and recommendations. This report presented Monsanto's short-term goals: "reduce the exposure in terms of liability," and "publicize actions where believed advantageous" by portraying to the public positive actions at correcting the contamination problem (MONS 035310, 11/10/1969).

A draft PCB Presentation was then prepared for the Corporate Development Committee in late 1969 / early 1970. Its express purpose was to acquaint the Committee "with the PCB (Aroclor) pollution problem and to secure [the Committee's] guidance and approval on a recommended plan of action. (MONS 058730, *circa* Dec 1969/Jan 1970). The Committee was informed that the PCB market was "one of Monsanto's most profitable franchises", which was "being threatened" by PCB "pollution problems." It was also apprised of a number of alternatives considered in light of the recent findings of PCBs in the environment, the potential for adverse legal and public relations problems, and the desire to maintain the PCB market. Monsanto stated it could not go out of the Aroclor business because "there is too much customer/market need and selfishly too much profit. . . ." Concerning open uses, the Committee was informed that PCB-containing Aroclors sold as plasticizers could cause contamination from leaching and vaporization; particularly sealants used in automotive, construction and joints were identified as possible PCB contamination sources due to "long-term leaching."

Monsanto notified by letter its U.S. distributors and customers of plasticizer-grade Aroclors 1254 and 1260 of the publicity surrounding PCBs, describing them as "potential" environmental contaminants and indicating that the lower chlorinated Aroclors presented no problem to the environment. Monsanto attached an article concerning water quality standards for each state (pH, temperature and dissolved oxygen, only) and referred its distributors and customers to the section regarding the need for good manufacturing practices to prevent the discharge of any materials in waterways but made no reference to PCBs. (DSW 318242, 2/19/1970; DSW 318245, 2/27/1970).

No details were provided on how PCB-containing Aroclors used as plasticizers in its customer's products were causing environmental contamination. Also, Monsanto informed its distributors that it was their responsibility to notify their customers of the information provided in Monsanto's letter, even though it contained no PCB specific information on how the environmental contamination had occurred nor how to prevent future environmental contamination from the handling of products formulated with plasticizer-grade Aroclors 1254 and 1260 (DSW 318242, 2/19/1970). There was no indication that Monsanto checked on whether its PCBs distributors alerted their customers even though Monsanto sold 4.5 million pounds of PCBs to distributors of plasticizers in 1968 alone (DSW 593170, 3/12/1969).

In a presentation to its sales personnel, Monsanto stated the purpose of the letters was to "minimize and, hopefully, eliminate claims made against us for environmental pollution damage." It was "merely fulfilling what [it] consider[ed] to be our moral and our legal responsibility to our customers". Monsanto stated the letter did not "imply guilt" or indicate its agreement with any of the published articles on PCB contamination. The letter further stated "Aroclor sales have increased every year for ten years – in boom or recession. We want 1970 to be no different." (TOWOLDMON0046386, *circa* 2/1970).

Talking points for sales personnel on how to handle plasticizer customers after they received the letter downplayed the publicity of PCB environmental contamination and minimized any customer concerns associated with continuing to use PCB-containing Aroclors as plasticizers

(TOWOLDMON0046386, circa 2/1970). The salesmen were told to state that PCB-containing Aroclors 1221, 1232, 1242, 1248, 1262, and 1268 were not persistent contaminants and posed no long-term threat. As discussed throughout this report, Monsanto had information that PCB-containing Aroclors were persistent in the environment.

In response to a hypothetical question of whether or not "Aroclor 1254/1260 could escape from my sealant/adhesive/coating" into the environment, Monsanto only provided the statement, "This will depend entirely on the final use to which your product is used—its ultimate disposition." As discussed previously, Monsanto's internal company documents showed that PCBs would escape from those products independent of the final use.

For a question regarding loss of Aroclor 1254 and 1260 vapors from a customer product, Monsanto stated, "Articles on PCB interference with pesticides analysis have mentioned the possibility of loss to atmosphere from vaporizations when Aroclor are heated. We find this hard to believe and it warrants considerable investigation." As discussed previously, Monsanto's internal company documents showed that PCBs as plasticizers volatilized from final polymer products at both ambient and elevated temperatures.

In response to a question about toxicity, the document suggested the misstatement, "The amounts being found in the environment are not considered a danger to humans or fish. The whole question on chlorinated pesticides relates to birds." If asked what they should tell their own customers, the sales personnel were told to avoid a direct answer by, "Tell your customer—We want to advise you of a possible environmental problem. Without knowing what your customer does with product X, this is hard to answer."

Monsanto, referring to the presentation made to its sales personnel, reiterated its strategy at the time: "We want to continue selling all Aroclors therefore play down the replacement bit and try to calm the customer" (DSW 318257, *circa* 2/1970). According to an internal memo from March 1970, Cumming Paton noted that the company received "little response to our PCB letter" and field sales had also received "little response" (DSW 318184, 3/31/1970).

In another internal report on a "Management Plan" for the PCB "Environmental Problem," Monsanto prefaced the discussion by noting "[m]ounting evidence has been noted that indicates PCB is ubiquitously present in the environment and is resulting in damage to the ecological system." Monsanto outlined several steps to support its overall objective, which was "to manage the PCB pollution problem to prevent it from adversely affecting the established Return-on-Investment objectives of the Functional Fluids and Plasticizers Groups, while maintaining the Corporate image of Monsanto as a responsible and respected member of industry worldwide." (PCB-ARCH0241548, 4/16/1970).

Back in February 1970 Monsanto also notified its functional fluids customers about the media attention on PCBs being discovered in "some marine, aquatic and wildlife environments" and the publicity surrounding the "potential problem of environmental contamination" from PCBs. It also stated that the PCBs found resembled Aroclor 1254 and 1260, which are in some functional fluids

such as a number of Pydrauls, Therminol FR-3, and certain capacitor and transformer fluids. Monsanto specifically pointed out that other Pydrauls, Turbinol 153 and the other Therminols did not contain Aroclor 1254 and 1260, and that the other Aroclors with less than 54% chlorine "have not been found in the environment" and presented "no potential problem."[52] Monsanto attached the article concerning water quality standards for each state (pH, temperature and dissolved oxygen, only) and referred its customers to the section regarding the need for good manufacturing practices to prevent the discharge of any materials in waterways but made no reference to PCBs (MONS089655, 2/9/1970; DSW 009726, 2/18/1970).

Similar to the plasticizer customer letter, Monsanto presented its employees with a list of questions and answers for use with functional fluids customers about the "Pollution Letter". It was strongly emphasized to personnel that Monsanto wanted customers to use up their inventory and not return fluids, particularly Pydraul. Customers were to be informed that Pydraul replacements would be available as a "top-off" and eventually "all Aroclor 1254 and Aroclor 1260 will be out of his system. <u>We don't want to take fluid back</u>."[53] Employees were also advised to demonstrate Monsanto's responsiveness to the environmental problem in order to maintain customer loyalty since "We can't afford to lose one dollar of business." (MONS 100123, 2/16/1970, *emphasis in original*).

The withdrawal of PCB-containing Pydrauls occurred over time. After the February 1970 customer notification that Aroclors resembling 1254 and 1260 were found in the environment and were used in some Pydraul products, Monsanto followed up with a letter in June 1970 stating it had reformulated several Pydrauls without PCBs that would be available as customers depleted the current inventory of PCB-containing Pydrauls. Then, in a letter dated April 15, 1971 Monsanto informed its Pydraul customers that "[t]here are now no PCBs in any of our Pydraul fluids." (MONS089994, 4/15/1971, emphasis in original). However, in an internal memo dated December 8, 1971, Monsanto noted that the April 15, 1971 letter was "not true" and it would "communicate immediately to the same customers clearly stating that this letter was somewhat in error." (HARTOLDMON0025543 @ 0025671, 12/8/1971). The following year, Monsanto notified its customers that it had "eliminated the use of any chlorinated compounds in our Pydraul fluids." (PCB-ARCH0299579, 7/17/1972).

Monsanto took a stepwise approach with ceasing sales of PCB-containing Therminol heat transfer fluids. After the February 1970 customer notification that Aroclors resembling 1254 and 1260 were found in the environment and were used in some Therminol products, Monsanto followed up with a letter in June 1970 stating it would no longer sell any PCB-containing Therminols to customers in the

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[52] As discussed earlier in Section VII.C., Monsanto had information that the lower chlorinated PCB congeners in Aroclor 1242 could degrade in the environment such that the remaining higher chlorinated PCB congeners appeared to resemble Aroclor 1254. Dr. Vodden, a PhD Chemist working for MCL in 1969, testified that Aroclor 1242 "look[ed] very much like Aroclor 1254, the product that people were claiming that they had found in the environment." (AMH Dec. - Dkt. 667, Ex. 22 [Vodden Deposition] 8/25/09).

[53] As noted in Section X.E. above, in a presentation at the 1975 National Conference on Polychlorinated Biphenyls, Hesse stated that hydraulic systems were as a major source of PCB contamination because "residues in discharge lines combined with loss of contaminated replacement fluids appear to result in continued low-level discharges." (Hesse, 1976).

food processing industry (PCB-ARCH0530922, 6/8/1970).[54] Monsanto continued to sell these heat transfer fluids to other industry sectors. In fact, Monsanto sold over 3.6 million pounds of PCB-containing Therminols in 1970 (DSW532590). In 1971, Monsanto ceased sales of PCB-containing Therminols for new heat transfer systems, while continuing to supply existing equipment (PCB-ARCH0078519, 11/16/1971). For example, Monsanto agreed to continue selling PCB-containing Therminol to the Chevron Oil Company for its heat transfer systems "presently utilizing Therminol FR products" not associated with any food processing (MONS089733, 9/1/1971). Finally, on December 15, 1971, Monsanto informed all Therminol customers that "effective this date" it would no longer sell PCB-containing Therminols. Monsanto cited its "concern" about "PCBs accumulating in the environment" and the problems that occurred from "accidental leakage of PCBs" from heat transfer systems (PCB-ARCH0633486, 12/15/1971).

D. Monsanto stopped sales of PCB-containing Aroclors for open use applications including plasticizers, for heat transfer applications in food processing, and for some hydraulic fluids/lubricants while permitting those customers to stockpile prior to discontinuance of the products.

In 1970, Monsanto terminated PCB sales "to a number of industrial users where there are inadequate possibilities of control, for such uses as pesticide extenders, medicinal, dental and cosmetic, and cutting oils. In addition, we are terminating all sales through distributors to ensure better control of end uses." (TOWOLDMON0001319, 4/20/1970). In a May 14, 1970 internal memo titled "1200 Series Aroclors; Removal of Products from Market," Monsanto set a timetable to "phase out of all non-biodegradable PCB products where control is not possible", which included the plasticizers because "none of our applications are considered to be of a controllable nature." Monsanto's timeline was to notify its key distributor accounts and Thiokol (the company that licensed the polysulfide liquid polymer) by early May 1970, followed by all distributors in late May, 1970 and then direct customers on June 1, 1970 (DSW 318071, 5/14/1970).

Monsanto's internal company documents revealed increasing reports of PCB contamination from plasticizer uses and the inability to control the release of PCBs into the environment from such applications.[55] However, Monsanto only informed its customers and distributors that its decision to discontinue the sale of PCB-containing products for modifier and plasticizer applications was based on "*allegations* that certain . . . PCBs had been found in the environment", and that their use as

[54] A letter to Monsanto indicated Monsanto's dissemination of information about the PCB problem was not sufficient. In May 1971 (almost one year since Monsanto announced it would no longer sell Therminol FR for food processing, it received a letter from a customer's attorney stating "Monsanto's decision to discontinue the sale of its Therminol FR series fluid in food processing plants came as a surprise. . .and [it] fails to see any great threat of PCB contamination to food products inasmuch as the FR-1 fluid is used only in a completely sealed system." (PCB-ARCH0444390, 5/18/1971).

[55] In a number of Monsanto's internal company documents, it noted that PCBs were being found in wildlife and the environment in different parts of the U.S. and the world. PCBs had been found in fish, oysters, shrimp and birds, fresh water and sediments, as well as "along coastlines of industrialized areas such as Great Britain, Sweden, Rhine River, low countries, Lake Michigan, Pensacola Bay, in Western wild life (eagles). (MONS 036714, 1969; MONS 030483, 9/5/1969; MONS 035310, 11/10/1969; MONS 058730, circa Dec 1969/Jan 1970).

plasticizers "*may* be a source of the *alleged* environmental contamination" (*emphasis added*) (MON-MT-003771, 6/1/1970).

Monsanto informed distributors of PCB-containing Aroclor plasticizers that it would continue to "accept orders through July 31, 1970 and [would] make every effort to meet these commitments and to complete shipment as of August 31, 1970" (MON-MT-003796, revised 8/14/1970). Monsanto documents indicated Monsanto permitted customers to stockpile PCB-containing Aroclors. A number of documents concerning communications with polysulfide sealants formulators in 1971, after Aroclors were no longer available for plasticizer applications, demonstrated Monsanto had permitted large amounts of PCB-containing Aroclors to be purchased for the continued use of PCBs in applications that Monsanto had stated internally were uncontrollable and in direct contact with the environment. For example, Pecora had typically bought around 100,000 pounds per year of primarily Aroclors 1254, 1260, and 1262 for the light construction industry. While working on reformulating, "they will stock up as much as they can." (TOWOLDMON0053377, 6/5/1970).[56]

On June 8, 1970 Monsanto advised its Therminol customers that the FDA "may place a maximum limitation on the quantity of PCB in food" and that Therminol fluids in food processing "does appear to present a potential source for contaminating food products with PCBs." Monsanto also informed them that it was no longer selling the Therminol fluids for applications with the potential for contaminating food after July 31, 1970 (PCB-ARCH0530922, 6/8/1970). This timeframe permitted those customers using PCB-containing Therminols to stock up in advance of the end date.

Similarly, on June 11, 1970 Monsanto informed its Pydraul customers that it had reformulated several Pydrauls without PCBs. Monsanto stated that those replacement formulations would be shipped out to customers as current inventory of PCB-containing Pydraul inventory in warehouses was depleted over 90 days (MONS090550, 6/11/1970). This timeframe permitted those customers using PCB-containing Pydrauls to stock up in advance of this end date.

Monsanto's PCB manufacturing and sales records indicated that despite the publicity on PCBs being a global contaminant, despite the letters that Monsanto sent to its customers and distributors, Monsanto produced and sold the most PCBs in the year 1970. In fact, PCBs sold for open uses, the one area of the market that Monsanto specifically targeted at discontinuing because the applications could not be controlled with regard to releases to the environment, peaked in 1970 (DSW 532590, no date).

Despite all of Monsanto's internal documents concerning PCBs as a persistent, environmental contaminant in the early 1970s, there was no mention by Monsanto in any of its communications with its polysulfide formulator customers of the fact that PCBs were toxic, volatile, persistent and bioaccumulative. For example, Monsanto's communications with the polysulfide sealants industry

[56] Sonneborn, Intercoastal, W.R. Grace and PRC, all formulators of polysulfide sealant, also purchased substantial quantities of Aroclors in an attempt to have a "stockpile" for one to two years (TOWOLDMON0053987, 5/25/1970; TOWOLDMON0053982, 6/3/1970; TOWOLDMON0053986, 6/17/1970; LEXOLDMON006714 @006717, 6/3/1970; TOWOLDMON0053985, 8/26/1970; TOWOLDMON0047364, 10/4/1971; TOWOLDMON0054521, 10/15/1970; TOWOLDMON0054537, 11/1971; TOWOLDMON0053051, 2/23/1971; TOWOLDMON0053052, 4/15/1971).

after the February "notification" letter was sent makes no mention of the letter (TOWOLDMON0053031, 3/9/1970; TOWOLDMON0053345, 4/30/1970). In a June 2, 1970 call report, Monsanto noted that PRC inquired if "PCB Aroclors [would] be manufactured anywhere in Western Hemisphere" since it has "plants in Canada and Mexico." (TOWOLDMON0053036, 6/2/1970). Monsanto's response to PRC was that it was "the only producer in this hemisphere. No others are expected." (TOWOLDMON0053035, 6/8/1970). Two months later a sales call report stated that PRC's Director of Research "continues to be antagonistic towards Monsanto for the posture we assumed regarding Aroclors. However, his attitude seems to have mellowed slightly, due to information he recently received from the New Jersey Board of Health" concerning the use of Aroclors. The call report noted the NJ Board of Health wrote PRC "a letter describing Aroclors as having extremely toxic effects on the human body thru the liver, when absorbed thru skin contact . . . it served to emphasize to [PRC] the seriousness of the pressure to which Monsanto has been submitted to recently regarding Aroclors." (TOWOLDMON0053038, 8/11/1970).

Koppers, a purchaser of Aroclors as plasticizers for coatings and other products, had accused Monsanto's action as being "unjustified and precipitous". Monsanto finally shed some light on the situation by informing Koppers that PCBs were ubiquitous in the environment, and that their use in plasticizers could not be tightly controlled so as to prevent environmental contamination. In addition, Monsanto admitted that the plasticizer market had to be sacrificed in order to continue using PCBs in other applications (MONS 089525, 7/1/1970; MONS 087409, 7/28/1970). Despite this exchange, Monsanto permitted Koppers to stockpile a significant amount of Aroclor 1254. A January 1972 internal memo noted Koppers had purchased "a four-year supply of liquid Aroclors. . . to last them through July of 1974." Monsanto did not tell them to stop using Aroclors despite noting that the "end use for which their product is used is too sensitive, i.e., swimming pool paints and potable water tank paints." (PCB-ARCH0030312, 1/31/1972). An internal call report from October 1972 indicated Koppers was "still working off their big 1254 inventory" for swimming pool paints more than two years since Monsanto announced it ceased sales (PCB-ARCH0495881, 10/12/1972). This action is an example of how Monsanto did not comply with corporate social responsibility standards because: (1) Monsanto's studies had showed PCBs were soluble in water and could accumulate in water; (2) the uses permitted direct human exposure to PCBs and (3) Monsanto's March 1970 technical bulletin on plasticizers specifically told customers not use PCBs in swimming pool paints (MONS 074441, 3/1970).

E. <u>Monsanto promoted and sold polychlorinated terphenyls (PCTs) and PCT blends that contained PCBs for plasticizers and other open use applications.</u>

Monsanto sold Aroclor 5460 (a PCT) for a variety for open use applications as a replacement for PCBs including adhesives, paints, and sealants. Yet, Aroclor 5460 actually contained PCBs. Monsanto internally reported approximately 10 million pounds of Aroclor 5460 had been sold in 1970 for plasticizer applications (HARTOLDMON0028203, no date). In the same document Monsanto planned to reduce PCBs in Aroclor 5460 from 1% to 0.5%.

Monsanto internally discussed the "hazard to children chewing on toys coated with a paint containing Aroclor 5460" in which Mr. Wheeler and Dr. Kelly had concluded (based on rat studies), "we do not believe this presents any significant hazard." The memo further noted that Aroclor 5460 would not "impart any additional toxicity to aluminum paint mixtures." (PCB-ARCH0069587, 3/11/1965).

Several Monsanto documents revealed that the company promoted Aroclor 5460 for food-type applications despite having information that the compound contained PCBs. Back in 1966 Monsanto discussed purification of Aroclor 5460 to decrease the concentration of chlorinated biphenyls. This discussion was a result of the FDA learning Aroclor 5460 "contain[ed] a small quantity of chlorinated biphenyl mixed in with the chlorinated terphenyl and quarterphenyls." After performing chicken feeding tests the "FDA have put two and two together and decided that the toxicity of 5460 may be due to this minor concentration of chlorinated biphenyl." (WATER_PCB-SD0000079992, 12/21/1966).

In 1968 Monsanto withdrew Aroclor 5460 from the FDA approval process for use in hot melt adhesives (HMA) for food packaging after receiving feedback from the FDA. Paton outlined "several problems" that they needed to overcome in order to obtain FDA approval in the future, including determining the chlorinated biphenyl content in the Aroclor 5460. Two years after the FDA identified "chlorinated biphenyl" content as a concern, Monsanto was still looking for ways to remove chlorinated biphenyl from Aroclor 5460 in order to obtain FDA approval for use in HMA. Monsanto reported that "36% of A-5460 sales go to hot melt adhesives where FDA approval is required in many applications." (TOWOLDMON0059220, 11/27/1968).

As Monsanto worked towards resubmission of Aroclor 5460 for FDA approval, several employees suggested it would be better to change the name of the product to Santicizer 5460 as this name had "a 'clean' sound", and since they "hope[d] to sell a lot" of it they didn't "want it linked to chlorinated biphenyls" even though as mentioned above PCBs were in the Aroclor 5460 (PCB-ARCH0176854, 6/18/1969). In early 1970 Monsanto was still attempting to quantify the range of chlorinated biphenyl concentrations found in Aroclor 5460. Process variation caused the chlorinated biphenyl content to be "high to excessive" in some lots. Monsanto concluded that the PCB content was higher "than was previously suspected" and, much like the FDA relayed in 1966, "the levels of PCB found could be an important factor in the toxicity status of Aroclor 5460." (PCB-ARCH0105003, 1/7/1970).

After Monsanto has informed customers it was withdrawing PCBs from the plasticizer market, its customers were pressing Monsanto for FDA approval of Aroclor 5460 for hot melt adhesives for food packaging. Monsanto communicated within its research department that they could "expand [Aroclor] 5460 use by gaining FDA regulation" (PCB-ARCH0623823, 6/17/1970). One customer noted that "once the approval is received, their consumption will increase many times over." (PCB-ARCH0487343, 9/7/1971). A sales call to Monsanto customer Superior Varnish revealed that despite "a considerable amount to work using A-5460 . . . in a new ink vehicle," "all work was stopped" after receiving Monsanto's letter to customers "stressing that PCT should not be used in food type

applications." The customer "felt that 5460 could not be used" since the inks "would go on beer cans, tooth paste containers, bread wrappers and the such." Monsanto's sales representative "requested that [the customer] contact Papageorge to get his views and see if 5460 could indeed be used in these printing applications." (PCB-ARCH0489321, 12/1/1971). At the end of that year Monsanto announced it was withdrawing Aroclor 5460 from the plasticizer market effective 3/31/1972 (WATER_PCB-00036587, 12/31/1971).

Monsanto also promoted Aroclor 5460 and the Aroclor 6000 series (Aroclor 1221 and 5460 blends including Aroclors 6062 and 6070) as a replacement plasticizer for A-1254 to paint manufacturers such as Glidden, Celanese Coatings and Hercules (PCB-ARCH0481813, 7/16/1970; PCB-ARCH0485894, 10/20/1971; PCB-ARCH0485673, 11/29/1971; PCB-ARCH0487236, 5/1970). Monsanto already had information that these customers made swimming pool paint and other chlorinated rubber coatings used on masonry surface (see Section VII.B on Parlon) (PCB-ARCH0485894, 11/18/1971; PCB-ARCH0487236, 5/1970). By the end of 1971, paint manufacturers such as Hercules were evaluating replacements for Aroclor 5460 (PCB-ARCH0487232; 12/20/1971).

During this same time period discussed above, Monsanto promoted and sold Aroclor 5460 for several other open uses. One such application was a new hot melt caulking for use in the homes of consumers that was very similar to the currently widely popular glue gun (PCB-ARCH0485295, 12/21/1970). Monsanto also marketed Aroclor 5460 for polyurethane carpet "underlay" for flame retardancy and as an alternative to chlorinated paraffin plasticizers, and promoted some "Santicizer" brand plasticizer blends that contained Aroclor 5460 for use in polysulfide sealants (PCB-ARCH0627049, 3/9/1971; PCB-ARCH0626700, 4/20/1971; PCB-ARCH0626702; 6/7/1971; PCB-ARCH0486851, 9/1/1971).

Throughout 1971, after Monsanto discontinued sales of PCB plasticizers for open uses due to environmental concerns, Monsanto fielded questions regarding the effect of PCTs on the environment. In a letter to Inmont Corporation addressing rumors that Monsanto was planning to remove more Aroclor products from the market, Monsanto insisted that they had never found PCTs in the environment, but neglected to mention that there were also PCBs in the PCT products (e.g. Aroclor 5460) (PCB-ARCH0000923, 3/12/1971). Later in 1971, Monsanto again insisted in letters to customers such as U.S. Plywood – Champion Papers and PRC, that although there was concern regarding using PCBs in open systems, PCTs were never found in the environment. Monsanto informed customers that the PCB content in the product is less than 0.4% by weight despite internal documentation that the PCB content was around 1% (MONS089783, 6/10/1971; PCB-ARCH0000725, 7/12/1971; HARTOLDMON0028203 @ 28227, undated). By the end of 1971, Monsanto informed customers it would no longer sell PCTs for "plasticizers and other open system applications" after 3/31/1972, which allowed customers to purchase them at normal volumes until that date (WATER_PCB-00036587, 12/31/1971).

F. Monsanto did not disclose its customers and sales of PCB-containing Aroclor products to government, scientists and the public in a timely manner, which delayed investigations into applications that were continuing to release PCBs into the environment.

Even before Monsanto withdrew PCBs from the plasticizer market an April 13, 1970 internal memo listed customers using PCB-containing Aroclor plasticizers in "a number of questionable applications." The list included customers, their applications and the distributor from which they were purchasing the Aroclor. Some notable applications of PCB-containing Aroclors in household products -- despite consistently stating otherwise when responding to government officials (Congressman Ryan) and the public-- included Kiwi Shoe Polish, Florasynth Labs and Perry Brothers Perfumes, and Halvorson Tree Co. "Xmas Tree Flameproofing and Sealing," as well as in fabric coatings and in dental labs. Another table listed the use of PCB-containing Aroclors in Curad Bandages (MON-MT-003143, 4/13/1970).[57]

Monsanto had several communications with New York Congressman William F. Ryan in 1970 concerning the PCBs. These communications reveal that Monsanto rejected numerous requests by Congressman Ryan to disclose vital PCB information. Specifically, Monsanto refused to provide the names of the PCB-containing products and the manufacturers of PCB-containing products, refused to provide production and sales figures of PCBs, and refused to identify all the uses of PCBs (DSW 526533, 4/21/1970; MONS 098443, 4/28/1970; DSW 203821, 6/18/1970; DSW 526543, 6/30/1970).

A Monsanto memo described Congressman Ryan's "total interest in the matter was to safeguard the health of the public. . . ." Congressman Ryan was clear that his primary concern was that, "PCBs are being used in the manufacture of household products which are handled by the public and could have an adverse effect on their health." Monsanto responded, "Aroclors were not used to any extent in these articles." (DSW 526533, 4/21/1970). Monsanto also informed Congressman Ryan that its production and sales figures were confidential information and would only release that information to Congressman Ryan "or any responsible government agency when we receive assurance that these figures will be kept confidential." (MONS 098443, 4/28/1970).

Congressman Ryan countered, "I am most disturbed by the PCB danger and what I consider Monsanto's unwillingness to deal candidly with a dangerous situation. Despite your assurances that PCBs are only used in closed systems, independent researchers have found them in the environment. I wonder if it surprises you to learn that Dr. Risebrough has discovered PCBs in paints bought at a Berkeley, California hardware store. Have you issued any warnings to all potential users of PCBs?" (DSW 203821, 6/18/1970).

Monsanto replied, "[w]e have not issued warnings to all potential users of chlorinated biphenyls, but we have more than covered this point by refusing to sell for applications where control cannot be established." Monsanto concluded the letter, "I hope that you will see fit to withdraw your allegations that Monsanto is unwilling to deal candidly with this issue." (DSW 526543, 6/30/1970).

[57] As discussed earlier, Monsanto marketed PCBs for many household uses, including floor waxes, furniture polish, paper draperies, table cloths, non-skid rug backings, etc.

As discussed above, during this same time period Monsanto had permitted its plasticizer customers to stockpile PCB-containing Aroclors so they could continue using them, specifically in applications "where control cannot be established." And, the documents show that the polysulfide sealant formulators did purchase large quantities of PCB-containing Aroclors for this purpose.

An article written by a reporter with the LA Times and picked up by a Madison, Wisconsin newspaper, *The Capital Times*, reported on the frustration by the scientific community to obtain information that Monsanto refused to provide on production figures for PCBs. The scientists were concerned with marine pollution by PCBs and needed production figures to assist in determining the amount of PCBs leaking into the environment (Fleming, 1970).

Monsanto also denied requests by the media and Dr. Risebrough to disclose PCB production information (DSW 203242, 12/8/1970; DSW 432285, 12/10/1970; DSW 432274; 12/10/1970; MONS 093213, 11/4/1971). Papageorge wrote a letter to Dr. Risebrough that stated, "Monsanto has been repeatedly accused of callously refusing to divulge usage data. On the contrary, we have on many occasions expressed our willingness to disclose to responsible members of governmental agencies on a confidential basis to enable them to correctly establish the present and future levels of PCB are escaping to the environment." (MONS 093213, 11/4/1971). Congressman Ryan had previously agreed to keep the information confidential, but had been turned down by Monsanto.

In a report addressing PCB residues in food and in the environment, the FDA also noted a lack of "adequate information on definite sources and routes of PCB entry into the environment . . . ." The organization further stated that "[a] greater effort should be made to establish sources of entry and if sources of this pollutant are established, they should be eliminated. . . . At this point, we are not assured that our current effort on PCB surveillance is offering maximum benefit (MONS 051270, 12/1970).

At the end of 1971, Monsanto finally released its total production and sales figures on PCB-containing Aroclors through 1971, but refused to divulge customer names, and quantities purchased by its customers (DSW 369806, 3/3/1972). Without this information, the sales figures alone did not permit the government and scientists to investigate sources of PCBs and legacy PCB contamination.

In 1975, Monsanto finally released to the EPA a customer list with respect to its sale of PCBs from 1971-1975, which by that time did not include Monsanto's past customers that purchased PCBs for use as plasticizers in open use applications or customers that had but were no purchasing PCB-containing Pydrauls and Therminols (DSW 011799, 8/8/1975). The list was wholly incomplete since it did not account for a significant number of customers formulating PCB-containing products that directly interfaced with the environment.

In a draft statement on "Environmental Presence of PCBs," Monsanto stated that PCBs sold for "open" uses were a "major source of PCBs entering the environment." (WATER_PCB-SD0000078536, 7/26/1975).

In 1979, Monsanto was found partly responsible in a Federal Court case concerning PCB contaminated minks. The source of the PCB contamination was bakery meal processed into poultry feed fed to ducks that were then fed to the minks. With regard to its responsibility, Monsanto stated that it had not communicated to the mink journals the potential for PCB contamination from mink food (MONS 011143, 6/11/1979). This case demonstrated the ubiquity of PCBs and Monsanto's responsibility to alert users of products that may have contained or were contaminated by PCBs.

Monsanto's delay in providing sufficient information to its employees, customers, end-users, governmental and regulatory agencies, and the public permitted continued sales of PCB-containing Aroclors for open use applications and semi-closed systems, which prevented timely inquiries into past PCB uses and legacy PCB contamination. This delay was not consistent with the principles of corporate responsibility as defined by Monsanto and in authoritative texts on the subject at the time.

XII. Conclusion

Monsanto manufactured, promoted and sold significant amounts of PCBs for open uses and in industrial fluids. Given the scientific and technical information acquired during Monsanto's production, marketing and sale of PCBs, Monsanto must have known that widespread use of PCBs for open use applications and in industrial fluids for semi-closed systems would result in pervasive and lasting environmental contamination and it failed to clearly disseminate or explain this scientific and technical information to its customers.

Monsanto did not act in accordance with the principles of corporate social responsibility by manufacturing, promoting and selling significant amounts of PCBs. Additionally, Monsanto did not act in accordance with these principles, even after the widespread presence of PCBs was identified and confirmed in the environment.

XIII. Literature References

***Authored by Monsanto*

Abt, C., 1974. "The Social Audit Technique for Measuring Socially Responsible Performance " in *Managing the Socially Responsible Corporation: the 1972-1973 Paul Garrett lectures*, edited by M. Anshen, Macmillan, New York.

American Chemical Society. 1965. *Plasticization and Plasticizer Processes*; A Symposium Sponsored by the Division of Industrial and Engineering Chemistry at the 147th Meeting of the American Chemical Society, Philadelphia, Pa., April 6–7, 1964. *Advances in Chemistry Series* 48. American Chemical Society, Washington.

Andersson, M., R.T. Ottesen, and T. Volden. 2004. "Building Materials as a Source of PCB Pollution in Bergen, Norway." *Science of the Total Environment* 325: 139-144.

"Aroclor 1248 Non-Inflammable Hydraulic Fluid." 1953. *Machinery* 82: 690-691.

Åstebro, A., B. Jansson, and U. Bergström. 2000. "Emissions During Replacement of PCB Containing Sealants – a Case Study." *Organohalogen Compounds* 46: 248-251.

ATSDR. 2000. Toxicological Profile for Polychlorinated Biphenyls (PCBs). U.S. Department of Health and Human Services.

Bailey, C.A., 1962. "How to Use Fire-Resistant Hydraulic Fluids." *Coal Age*. 67(12): 88-92.

Bennett, G.A., C.K. Drinker, and M.F. Waren. 1938. "Morphological Changes in the Livers of Rats Resulting from Exposure to Certain Chlorinated Hydrocarbons." *The Journal of Industrial Hygiene and Toxicology* 20 (2): 97–123.

Bird, D. 1970. "Curb Urged in Use of PCB Chemical." *New York Times*, April 11, p. 30.

Boller, L. 1976. "Polysulfide Sealants." In *Building Seals and Sealants*, edited by J Panek, 40–53. ASTM International: West Conshohocken, PA.

Boyer, R.F. 1949. "The Compatibility, Efficiency and Permanence of Plasticizers." *Journal of Applied Physics* 20 (6): 540–52.

Boyer, R.F. 1951. "Effect of Plasticizers on Some Physical Properties of Polymers." *Tappi* 34 (8): 357–62.

Boyle, R. H. 1970. "Poison Roams Our Coastal Seas." *Sports Illustrated* 33 (17): 71-84.

Brown, R.M. 1947. "On the Toxicity of the 'Aroclors'." *The Chemist Analyst* 36(2): 33–35.

C&E News, 5/29/1950, 9/25/1950, 2/26/1951, 8/25/1952, and no date. *Chemical and Engineering News*.

***"Monsanto Girds for Heat Transfer Fluids Push." May 1962. *Chemical and Engineering News* (C&E News).

***Craver, J.K. 1948. "Mechanism of Plasticization in Plastics." American Society for Testing Materials – Bulletin No. 152: 90–92.

Curren, J., S. Bush, S. Ha, M.K. Stenstrom, S.-L. Lau, I.H.M. Suffet. 2011. "Identification of Subwatershed Sources for Chlorinated Pesticides and Polychlorinated Biphenyls in the Ballona Creek Watershed." *Science of the Total Environment* 409: 2525–2533.

Curry, N.A., 1976. "Controlling PCB Discharges to the Environment", *Proceedings of the Ontario Industrial Waste Conference*, pp 449-473.

Dalbke, R.G., A.M. Tenny and H. Baumert. 1965. "Problems in Detecting and Controlling Oils, Fats and Greases at Their Source. Lubrication Engineering. October, pp. 433-435.

***Davis, W. J. and P.G. Benignus. 1963. "Therminol FR-2 Heat Transfer Systems." *Chemical Engineering Progress* 59(5): 39-42.

deVoogt, P.DE. and U.A.Th. Brinkman, 1989. "Production, properties and usage of polychlorinated biphenyls." In Halogenated biphenyls, terphenyls, naphthalenes, dibenzodioxins and related products. R.D. Kimbrough and A.A. Jensen (eds). New York: Elsevier Science Publishers. pp. 3 – 45.

Diamond, M.L. and E. Hodge. 2007. "Urban Contaminant Dynamics: From Source to Effect." *Environmental Science and Technology*, 41 (11): 3796-3805.

Diamond, M.L., L. Melymuk, S.A. Csiszar, and M. Robson. 2010. "Estimation of PCB Stocks, Emissions, and Urban Fate: Will our Policies Reduce Concentrations and Exposure?" *Environmental Science and Technology*, 44: 2777-2783.

Diefenbacher, P.S., C. Bogdal, A.C. Gerecke, J. Glüge, P. Schmid, M. Scheringer, and K. Hungerbühler. 2015. "Emissions of Polychlorinated Biphenyls in Switzerland: A Combination of Long-Term Measurements and Modeling." *Environmental Science and Technology* 49: 2199–2206.

Doolittle, A.K. 1954. The Technology of Solvents and Plasticizers. New York: Wiley.

Dourson, M.L. and J.F. Stara. 1983. "Regulatory History and Experimental Support of Uncertainty (Safety) Factors." *Regulatory Toxicology and Pharmacology* 3:224-238.

Drinker, C.K., M.F. Waren, and G.A. Bennett. 1937. "The Problem of Possible Systemic Effects from Certain Chlorinated Hydrocarbons." *The Journal of Industrial Hygiene and Toxicology* 19 (7): 283–311.

Drinker, C.K. 1939. "The Problem of Possible Systemic Effects from Certain Chlorinated Hydrocarbons." *The Journal of Industrial Hygiene and Toxicology* 21 (5): 155–159.

Duke, T.W., J.I. Lowe, and A.J. Wilson, Jr., 1970. "A Polychlorinated Biphenyl (Aroclor 1254) in the Water, Sediment, and Biota of Escambia Bay, Florida." *Bulletin of Environmental Contamination & Toxicology*. 5(2): 171-180.

Department of Ecology, 2016. Polychlorinated Biphenyls in Consumer Products. Publication No. 16-04-014.

Eisenreich, S.J, G.J. Hollod, and T.C. Johnson. 1979. "Accumulation of Polychlorinated Biphenyls (PCBs) in Surficial Lake Superior Sediments. Atmospheric Deposition." *Environmental Science and Technology* 13(5): 569–573.

***Emerson, W.S., R.I. Longley, Jr., J.R. Darby, and E.E. Cowell. 1950. "Oxaglycol Esters as Polyvinyl Chloride Plasticizers." *Industrial and Engineering Chemistry* 42 (7): 1431-1433.

Electric Power Research Institute (EPRI), 1999. <u>The PCB Information Manual. Volume 1: Production, Uses, Characteristics, and Toxicity of PCBs</u>. December. TR-114091-V1.

Erickson, M.D. and R.G. Kaley, II, 2010. "Application of polychlorinated biphenyls." *Environmental Science and Pollution Research*. 18: 135-151.

Everz, M., 1957. "Fire-resistant hydraulic fluids means safer die casting." *The Tool Engineer*. 39(4): 113-115.

Federal Register, 1976. "Polychlorinated Biphenyl-Containing Wastes." 41(64): 14134-14136 Thursday, April 1.

Federal Specification TT-S-230A. May 5, 1967. "Sealing Compound, Synthetic-Rubber Base, Single Component Chemically Curing (for Calking, and Glazing in Building Construction)." http://everyspec.com/FED_SPECS/T/TT-S-230A_11260/.

Fleming, L.B., 1970. "Scientists Balked on Pollution Data." *The Capital Times*. December 10.

Foster, G.D. and V. Cui. 2008. "PAHs and PCBs deposited in surficial sediments along a rural to urban transect in a Mid-Atlantic coastal river basin (USA)." *Journal of Environmental Science and Health Part A* 43: 1333–1345.

Fulton, W.B. and J.L. Matthews. 1936. "A Preliminary Report of the Dermatological and Systemic Effects of Exposure to Hexachloro-Naphthalene and Chloro-Diphenyl." Bureau of Industrial Standards – Special Bulletin No. 43: 3–15.

***Garrett, J.T. 1957. "Toxicity Considerations in Pollution Control." *Industrial Wastes* 2 (1): 17–19.

Gerstacker, C., 1974. "Creating a Management Environment for Socially Responsible Performance " in *Managing the Socially Responsible Corporation*: the 1972-1973 Paul Garrett lectures, edited by M. Anshen, Macmillan, New York.

Gibbs, C.W., 1971. <u>Compressed Air and Gas Data</u>. 2nd Edition. New Jersey: Ingersoll-Rand Company.

Gingrich, S.E., M.L. Diamond, G.A. Stern, and B.E. McCarry. 2001. "Atmospherically Derived Organic Surface Films along an Urban-Rural Gradient." *Environmental Science and Technology* 35: 4031−4037.

Golding, B. 1959. *Polymers and Resins: Their Chemistry and Chemical Engineering*. Princeton, NJ: D.Van Nostrand Company, Inc.

Greenburg, L., M.R. Mayers and A.R. Smith. 1939. "The Systemic Effects Resulting from Exposure to Certain Chlorinated Hydrocarbons." *The Journal of Industrial Hygiene and Toxicology* 21 (2): 29-37.

Guo, Z., X. Liu, K.A. Krebs, D.J. Greenwell, N.F. Roache, R.A. Stinson, J.A. Nardin, and R.H. Pope. 2012. Laboratory Study of Polychlorinated Biphenyl (PCB) Contamination and Migration in Buildings: Part 2. Transport from Primary Sources to Building Materials and Settled Dust. U.S. EPA Report: EPA/600/R-11/156A.

Gustafson, C.G. 1970. "PCB's–Prevalent and Persistent." *Environmental Science and Technology* 4 (10): 814-819.

Harrad, S.J., A.P. Sewart, R. Alcock, R. Boumphrey, V. Burnett, R. Duarte-Davidson, C. Halsall, G. Sanders, K. Waterhouse, S. R. Wild, and K.C. Jones. 1994. "Polychlorinated Biphenyls (PCBs) in the British Environment: Sinks, Sources and Temporal Trends." *Environmental Pollution* 85: 131-146.

***Hatton, R.E. 1962. *Introduction to Hydraulic Fluids*. New York: Reinhold Publishing Corporation.

Hemeon, J.R., 1955. "Changing to fire-resistant fluid?" *Applied Hydraulics*. 8(7):86-88.

Herrick, R.F., M.D. McClean, J.D. Meeker, L.K. Baxter, and G.A. Weymouth. 2004. "An Unrecognized Source of PCB Contamination in Schools and Other Buildings" *Environmental Health Perspectives* 112 (10): 1051-1053.

Herrick, R.F. Lefkowitz, and G.A. Weymouth. 2007. "Soil Contamination from PCB-Containing Buildings." *Environmental Health Perspectives* 115(2): 173-173.

Hesse, J.L., 1976. "Polychlorinated Biphenyl Usage and Sources of Loss to the Environment in Michigan." In Conference Proceedings of the National Conference on Polychlorinated Biphenyls, November 19-21, 1975. Chicago, Illinois. EPA-560/6-75-004. pp. 127-133.

Houser, T.V. 1957. *Big Business and Human Values*. New York: McGraw-Hill Book Company, Inc.

Hsu, Y.-K., T.M. Holsen, and P.K. Hopke. 2003. "Locating and Quantifying PCB Sources in Chicago: Receptor Modeling and Field Sampling." *Environmental Science and Technology* 37: 681−690.

Hwang H.-M. and G.D. Foster. 2008. "Polychlorinated Biphenyls in Stormwater Runoff Entering the Tidal Anacostia River, Washington, DC, Through Small Urban Catchments and Combined Sewer Outfalls." *Journal of Environmental Science and Health, Part A* 43(6): 567-575.

"Hydraulic Fluid Cuts Mill Overhead." 1968. *Iron Age*. 202(16): 74-75.

Interdepartmental Task Force on PCBs (ITF), 1972. Polychlorinated Biphenyls and the Environment.

Irvine, K.N. and B.G. Loganathan. 1997. "Localized Enrichment of PCB Levels in Street Dust Due to Redistribution by Wind." *Water, Air, and Soil Pollution* 105: 603–615.

Jartun, M., R.T. Ottesen, E. Steinnes, and T. Volden. 2009. "Painted surfaces – Important Sources of Polychlorinated Biphenyls (PCBs) Contamination to the Urban and Marine Environment." *Environmental Pollution* 157: 295–302.

Jartun, M. and A. Pettersen. 2010. "Contaminants in Urban Runoff to Norwegian Fjords." *Journal of Soils and Sediments* 10: 155–161.

***Jenkins, R.L. and R.N. Foster. 1931. "Compatibility Relationships of Aroclors in Nitrocellulose Lacquers." *Industrial and Engineering Chemistry* 23 (12): 1362–1365.

Kleinert, S.J., 1976. "Sources of Polychlorinated Biphenyls in Wisconsin." In Conference Proceedings of the National Conference on Polychlorinated Biphenyls, November 19-21, 1975. Chicago, Illinois. EPA-560/6-75-004. pp. 124-126.

Klosterhaus, S., L.J. McKee, D. Yee, J.M. Kass, A. Wonget. 2014. "Polychlorinated Biphenyls in the Exterior Caulk of San Francisco Bay Area Buildings, California, USA." *Environment International* 66: 38–43.

Kohler, M., J. Tremp, M. Zennegg, C. Seiler, S. Minder-Kohler, M. Beck, P. Lienemann, L. Wegmann, and P. Schmid. 2005. "Joint Sealants: An Overlooked Diffuse Source of Polychlorinated Biphenyls in Buildings" *Environmental Science and Technology* 39: 1967-1973.

Kuratsune, M. and J. Matsuzaka, 1971. "Yusho, a poisoning caused by rice oil contaminated with polychlorinated biphenyls." *HSMHA Health Reports*. 86(12):1083-1091.

***Langenfeld, F.H. 1957. "Fire-Resistant Hydraulic Fluids for the Die Casting Industry, Part 3: Phosphate Ester Base Types" *Precision Metal Molding* March: 97-104.

Lehman, A.J. and O.H. Fitzhugh. 1954. "100-Fold Margin of Safety." *Association of Food & Drug Officials of the US Quarterly Bulletin* XVIII (1): 33–35.

Lewis, R.G., B.E. Marin, D.L. Sgontz, and J.E. Howes, Jr. 1985. "Measurement of Fugitive Atmospheric Emissions of Polychlorinated Biphenyls from Hazardous Waste Landfills." *Environmental Science and Technology* 19: 986−991.

Lufkin, D., 1974. "Some Financial Implications of Corporate Social Responsibility" in *Managing the Socially Responsible Corporation:* the 1972-1973 Paul Garrett lectures, edited by M. Anshen, Macmillan, New York.

Mackay, D. and A.W. Wolkoff. 1973. "Rate of Evaporation of Low-Solubility Contaminants from Water Bodies to Atmosphere." *Environmental Science and Technology* 7(7): 611−614.

MacLeod, K.E. 1979. Sources of Emissions of Polychlorinated Biphenyls into the Ambient Atmosphere and Indoor Air. U.S. EPA Report: EPA-600/-78-00.

MacLeod, K.E. 1981. "Polychlorinated Biphenyls in Indoor Air" *Environmental Science and Technology* 15 (8): 926-928.

Manufacturing Chemists Association (MCA), July 18, 1939. National Paint, Varnish and Lacquer Association.

***McArdle, M., L.C. Garrett, and P.G. Benignus. 1948. "An Indirect Aroclor Heater for Unit Chemical Operations" Industrial and Engineering Chemistry 41 (7): 1341-1344.

Meigs, J.W., J.J. Albom, and B.L. Kartin. 1954. "Chloracne from an Unusual Exposure to Aroclor." *Journal of the American Medical Association* 154 (17): 1417-1418.

Mellan, I. 1961. *The Behavior of Plasticizers*. New York: Pergamon Press.

Merriam-Webster, 2016. *https://www.merriam-webster.com/dictionary/plasticizer*

Miller, J.W. 1944. "Pathologic Changes in Animals Exposed to a Commercial Chlorinated Diphenyl" *Public Health Reports* 59 (33): 1085-1093.

Miller, S.M., M.L. Green, J.V. Depinto, and K.C. Hornbuckle. 2001. "Results from the Lake Michigan Mass Balance Study: Concentrations and Fluxes of Atmospheric Polychlorinated Biphenyls and trans-Nonachlor." *Environmental Science and Technology* 35: 278−285.

Mitchell, R.L., 1964. "Advantages of a Well-Conceived Die Cast Safety Program." Transactions of the Society of De Casting Engineers. pp.1-5

***Monsanto Chemical Company. 1947. "For Your Information: News of Monsanto Chemicals for the Process Industries." *Industrial and Engineering Chemistry*, Advertisement, December 1.

Robbins, P.H., 2017. Building for Professional Growth: A History of the National Society of Professional Engineers 1934-1984. National Society of Professional Engineers.

New Scientist. 1966. "Report of a New Chemical Hazard." In Notes on the News. *New Scientist*, p 612.

Nisbet, I.C. and A.F. Sarofim, 1972. "Rates and Routes of Transport of PCBs in the Environment." *Environmental Health Perspectives*. April. 1: 21-38.

Nottoli, J.A.; and R.B., Jacko, 1990, "Atmospheric PCB flux rate determination following a localized soil spill", *American Society of Mechanical Engineers, Petroleum Division* (28): 1-5.

O'Neill, P.A., 1993. Industrial Compressors. Oxford: Butterworth-Heinemann.

***Penning, C.H. 1930. "Physical Characteristics and Commercial Possibilities of Chlorinated Diphenyl." *Industrial and Engineering Chemistry* 22 (11): 1180-1182.

Perlman, D. 1969. "A Menacing New Pollutant." *San Francisco Chronicle* 105 (55): 1, 20.

Peterson, E.A., B.W. Pozniak, D.J. Smith, and A.D. Yazujian. 1976. "Polysulfide Rubber." In *Building Seals and Sealants*, edited by J Panek, 11–39. ASTM International: West Conshohocken, PA.

Priha, E., S. Hellman, and J. Sorvari. 2005. "PCB Contamination from Polysulphide Sealants in Residential Areas—Exposure and Risk Assessment." *Chemosphere* 59: 537–543.

Reed, M.C. 1943. "Behavior of Plasticizers in Vinyl Chloride-Acetate Resins." *Industrial and Engineering Chemistry* 35 (8): 869–904.

Reed, M.C. 1947. "Survey of Plasticizers for Vinyl Resins." *Journal of Polymer Science* 2 (2): 115–20.

Robson, M., L. Melymuk, S.A. Csiszar, A. Giang, M.L. Diamond, and P.A. Helm. 2010. "Continuing Sources of PCBs: The Significance of Building Sealants." *Environment International* 36: 506–513.

Rollins, J.P., 1989. Compressed Air and Gas Handbook. 5th Edition. New Jersey: Prentice Hall.

Rossi, L., L. de Alencastro, T. Kupper, and J. Tarradellas. 2004. "Urban Stormwater Contamination by Polychlorinated Biphenyls (PCBs) and Its Importance for Urban Water Systems in Switzerland." *Science of the Total Environment* 322:179–189.

Sax, N.I. 1951. *Handbook of Dangerous Materials*. New York: Reinhold Publishing Corporation.

Schwartz, L. 1936a. "Dermatitis from Synthetic Resins and Waxes." *American Journal of Public Health* 26: 586-592.

Schwartz, L. 1936b. "Dermatitis in the Manufacture of Synthetic Resins and Waxes." Skin Hazards in American Industry, Part II. *Public Health Bulletin* No. 229, pp 1-12.

Shen, T.T. and T.J. Tofflemire. 1980. "Air Pollution Aspects of Land Disposal of Toxic Wastes." Journal of the Environmental Engineering Division, Proceedings of the American Society of Civil Engineers, Vol. 106, No. EE1, pp 211-226.

Small, P.A. 1947. "The Diffusion of Plasticisers from Polyvinyl Chloride." *Journal of the Society of Chemical Industry* 66 (1): 17–19.

Stark, T.D., H. Choi, and P.W. Diebel, 1982. Plasticizer Molecular Weight and Plasticizer Retention in PVC Geomembranes. In 57th Canadian Geotechnical Conference

Sundahl, M., E. Sikander, B. Ek-Olausson, A. Hjorthage, L. Rosell and M. Tornevall. 1999. "Determinations of PCB Within a Project to Develop Cleanup Methods for PCB-Containing Elastic Sealant Used in Outdoor Joints Between Concrete Blocks in Buildings." *Journal of Environmental Monitoring* 1: 383-387.

Sykes, R.G. and A.R. Coate. 1995. "PCBs in Sealants in Water Distribution Reservoirs." *Journal of the American Water Works Association*, Vol. 87, No. 4, Arsenic Removal (APRIL 1995), pp. 96-100.

Treon, J.F., F.P. Cleveland, J.W. Cappel and R.W. Atchley. 1956. "The Toxicity of the Vapors of Aroclor 1242 and Aroclor 1254." *American Industrial Hygiene Association Quarterly.* 17 (2): 204-213.

Uhl, P.W. 1954. "Oily Industrial Wastes" *Lubrication Engineering*. April, pp.87-88.

US EPA, 1979. *Polychlorinated Biphenyls 1929-1979: Final Report*. Office of Toxic Substances. Contract No. 68-01-3259. Submitted by: Versar, Inc. Springfield, VA. May, 16 1979.

US EPA, 2010 - *https://www.epa.gov/sites/production/files/2015-08/documents/research-plan.pdf*

US EPA, 1976. PCBs in the United States Industrial Use and Environmental Distribution. Contract 68-01-3259. Submitted by Versar, Inc. Springfield, VA. February 25, 1974.

Von Wedel, H., W.A. Holla, and J. Denton. 1943. "Observations on the Toxic Effects Resulting from Exposure to Chlorinated Naphthalene and Chlorinated Phenyls with Suggestions for Prevention." *Rubber Age* 53 (5): 419-426.

"What They Say about Leakage Control." 1957. *Applied Hydraulics*. 10(5): 81-85, 156.

Whitehead, T.P., F.R. Brown, C. Metayer, J-S. Park, M. Does, J. Dhaliwal, M.X. Petreas, P.A. Buffler and S.M. Rappaport. 2014. "Polychlorinated Biphenyls in Residential Dust: Sources of Variability." *Environmental Science and Technology* 48 (1): 157-164.

APPENDIX A

Matson CV

Matson 4 Year Case History

MATSON & ASSOCIATES

Updated 4/2019

Jack V. Matson, Ph.D., P.E.

Matson & Associates, Inc
331 East Foster Avenue State College, PA 16801
P: 814-231-5253 | E: jmatson@matson-associates.com
www.matson-associates.com

EDUCATION

Ph.D., Environmental Engineering, Rice University, 1974

M.S., Chemical Engineering, University of Toledo, 1968

B.S., Chemical Engineering, University of Toledo, 1965

PROFESSIONAL EXPERIENCE

Founder, Principal Engineer, Testifying Expert and Consultant
Matson & Associates, Inc., 1980 - present

Professor of Environmental Engineering (Emeritus)
The Pennsylvania State University, 1992-2009 (2010)

Chairman of the Regulation Development & Enforcement Committees
Texas Air Control Board, 1991-1993

Adjunct Professor of Environmental Health
University of Texas School of Public Health, 1986-1992

Assistant, Associate Professor of Civil and Environmental Engineering
University of Houston, 1974-1992

Manager of Environmental Engineering Design Section
S & B Engineers, Houston, Texas, 1970-1971

Chemical / Environmental Engineer
Enjay Chemicals (now Exxon), Baytown, Texas, 1968-1970

Process Chemical Engineer
Sun Oil Refinery, Toledo, Ohio, 1964-1965

LICENSES

Registered Professional Engineer
Ohio (34696)
Pennsylvania (71657)

SUMMARY OF QUALIFICATIONS

Dr. Matson has nearly fifty years of experience in the field of chemical and environmental engineering. He has extensive experience working for industry as a process chemical engineer at both an oil refinery and a chemical plant, and as an environmental engineering consultant for chemical manufacturing facilities. As a professor, he taught courses on environmental engineering, environmental chemistry, engineering design, hazardous waste management, and environmental law and regulation. In addition, he conducted research and supervised research of master's students and doctoral candidates in areas including environmental chemistry, chemical engineering, and chemical emissions from industrial facilities. Dr. Matson has provided expert opinions in over 100 cases involving chemical

contamination of the environment. His expertise is in chemical emissions, historical industry knowledge and environmental regulations. Chemicals of concern include PCBs, dioxin, hexavalent chromium, arsenic, lead, chlorinated solvents, pesticides, PAHs, benzene, ammonium perchlorate and constituents associated with petroleum.

DIRECT EXPERIENCE WITH PCBS

Dr. Matson began researching the status of PCBs in the environment in 1974 for a paper titled "The Effects and Fate of PCBs in the Environment" written for a course in Chemical Contamination of the Environment at the University of Texas' School of Public Health. Since that time he has been a consultant to industry and the community on PCB environmental issues, and an expert witness in a number of cases concerning PCB emissions from various industrial facilities. Dr. Matson has reconstructed PCB emissions to the air, water and land from industrial sources and has testified on standard of care issues pertaining to PCB discharges into rivers and releases to the land throughout the U.S. He has also testified on expected / intended issues in insurance recovery cases relating to the presence of PCBs in the environment. In cost allocation cases, Dr. Matson has provided testimony on the source or contributor of PCBs to contaminated sites requiring cleanup efforts.

Toxic Tort, Property Damage, Nuisance

- Opined on continuing sources of PCB discharges and on standard of care issues associated with the disposal of PCBs at a nylon facility in Pensacola, FL.
- Opined on standard of care issues pertaining the manufacture and sale of PCBs for paint associated with PCB contamination of Big Spring Creek (Lewistown, MT) from paint used at a fish hatchery.
- Opined on standard of care issues in three cases involving the handling and disposal of PCBs at a transformer manufacturing facility resulting in PCB contamination in the city-owned lake, and residential and commercial properties in Crystal Springs, MS.
- Opined on standard of care issues pertaining to Monsanto's practices concerning the manufacture and release of PCBs from its plant in Anniston, AL. Reconstructed historical PCB emissions to the air, water and soil.
- Opined on PCB emissions from the French Limited Superfund dump site in Crosby, TX.

Insurance Recovery

- Opined on expected / intended issues concerning PCB contamination in soils at a former chemical manufacturing and blending facility located in Lodi, NJ.
- Opined on expected / intended issues concerning PCB contamination of the Lower Fox River. Analyzed operations and discharges from a number of PRPs including a paper manufacturing plant, a coating plant and a paperboard manufacturing facility.
- Opined on expected / intended issues concerning the use and discharge of PCB-containing hydraulic fluid at an aluminum die cast facility that resulted in sediment contamination of Cedar Creek (Cedarburg, WI).

Cost Allocation

- Opined on whether PCBs found on the site of a former truck washing facility (St. Louis, MO) posed an imminent and substantial endangerment as defined under RCRA 7002.
- Opined on whether the source of PCBs found at the site of a former asphalt manufacturing plant came from PCB-contaminated waste transformer oil, Seattle, WA.
- Opined on whether a manufacturing facility contributed to the PCBs found in a waterway connected to the Duwamish River from the historical use of a PCB-containing lubricant (Seattle, WA).

Consulting

- Provided litigation support for a client involved in a lawsuit concerning PCBs found in the environment at an aluminum die-cast facility and neighboring properties. Researched and evaluated the historic operations concerning the use, handling and disposal of PCB-containing / contaminated hydraulic fluids to identify sources and timing of releases, and whether the facility anticipated harm to the environment due to its handling and disposal practices.
- Provided litigation support for clients involved in a lawsuit concerning remediation of the sediments in the Hudson and Housatonic Rivers from the use, handling, and disposal of PCBs during the manufacture of transformers and capacitors. Contamination of the groundwater by chlorinated solvents and PCBs were also an issue in the case.
- Consultant to the Catholic Diocese on a church site adjacent to the Geneva Superfund Site on the potential ramifications of PCB contamination, Houston, TX.

OTHER PROFESSIONAL PROJECTS

- "Change, Where Do I Go from Here?" Originator and Teacher, Centre County Correctional Institute, 2016 to present
- Lion Launch Pad Advisor, Penn State, 2016 to 2018
- "Creativity, Innovation, and Change," Massive Open On-line Course (MOOC), Originator and Project Manager, Penn State, 2013 to present
- Penn State College of Education Doctoral Program, Mentor, 2010 to present
- Freshman Seminar, Entrepreneurship, Penn State, 2010 to 2018
- NASA, Innovative Engineering, Co-originator, 2009 to present
- Energy efficiency of window seals for a window seal manufacturer, 2008
- Predictive modeling tool for chemical additions to maintain cooling water chemistry in natural draft and mechanical draft cooling towers, Air Liquide, Delaware, 2005-2010
- Indoor air quality analysis and source identification for the presence of TCE, Luzerne Intermediate Unit, Pennsylvania, 2004

- Member of the Rutgers Chemical Advisory Committee for the Rutgers Superfund Site, State College, Pennsylvania, 2003-2004
- Review of expert reports concerning community exposure to PAHs from coke dust emissions in Long Beach and Los Angeles, CA, 2003.
- Source identification of specific chemicals present in an historical dump site used by multiple parties, Petrolia, Pennsylvania, 2002-03
- Zero Discharge Feasibility Study, Alcoa, Point Comfort, Texas, 1995-96
- Zero Discharge Feasibility Study, Formosa Chemicals, Point Comfort, Texas, 1994-98
- Heavy Metals in Municipal Sludge, HouTurf, Houston, Texas, 1992
- Member of the Health, Safety, and Environment Task Force retained by Westinghouse to inspect and make recommendations with respect to mixed wastes including **PCBs** at the Hanford Nuclear facility (Washington), 1993
- Maximum Recycle Design at the Unocal Santa Maria, CA Refinery, 1992
- Evaluation of Site Assessment, Perry, Houston, Texas, 1991
- Sources and Fate of Dioxin, Houston, Texas, 1990-91
- Cooling Water Discharges, Aristech, Houston, Texas, 1990-91
- Environmental Assessments, Tom Gray, Houston, Texas, 1990-91
- Dynamic Filter Study, Ashbrook-Simon-Hartley, Houston, Texas, 1990
- Produced Water Discharge, Eaton, Houston, Texas, 1989
- Evaluation of RCRA Violations at Baytank, Houston, Texas, EPA, 1988
- Industrial Waste Treatment, Seatex Corporation, Houston, Texas, 1988
- STAR Consultant for United Nations Industrial Development Organization to lecture and assist Sinopec Oil in the Peoples Republic of China in industrial water recycle, July 14-August 1, 1988 in Beijing, China.
- Process Design of the City of Houston 69th Street Sewage Treatment Plant; Lockwood Andrews, and Newman, Houston, Texas, 1975-76
- Methane Gas Generation from a Landfill, City of Beaumont, Texas, 1975
- Process Design, Instrumentation and Control of a Sidestream Softener for Zero Discharge, Arco Polymers, Inc., Houston, Texas, 1973-78

PATENTS

Matson, J.V, and Kennon, D.S., "Green Biodiesel," US Patent No. 7563915, Issued on May 25, 2009.

Co-inventor with Hight, T.V., et al., "Biocidal Methods and Compositions for Recirculating Water Systems, U.S Patent No. 5,464,636, Issued on November 7, 1995; U.S. Patent No. 5,476,670, Issued on December 19, 1995; U.S. Patent No. 5,527,547, Issued on June 18, 1996; and U.S. Patent No. 5,662,940, Issued on September 2, 1997.

Matson, J.V., "Industrial Wastewater Reuse by Selective Silica Removal over Activated Alumina," U.S. Patent No. 4,296,180, Issued on June 30, 1981.

ROYALTY AGREEMENT

University of Houston with Monsanto for Exclusive Rights to produce and market "Towerbrom." 1989-1992; transferred to Occidental Chemical Corporation.

RECOGNITION OF TEACHING

Zell/Lurie Award and Fellowship for the Teaching of Innovation, University of Michigan.

The University of Houston Teaching Excellence Award, 1991, Amoco Foundation.

General Electric Learning Excellence Award, Penn State College of Engineering, 2003.

Garrey Carruthers Chair in Honors at the University of New Mexico for 2007-08 academic semester

PUBLICATIONS

Book
Matson, J.V. Effective Expert Witnessing, 5th Ed., CRC Press, 2012

Articles

- Matson, J.V., and R.J. Schuhmann, "Natural Attenuation as a Remedy Not an Excuse," Journal of Soil Contamination, 8(1) 29-33, 1999.
- Ballard, C., and J.V. Matson, "Precise Prediction of pH in Cooling Water," Journal of the Cooling Tower Institute, Vol. 12, pp. 30-38, 1992.
- Zhang, Z. H., and J.V. Matson, "Organic Halogen Stabilizers," Journal of the Cooling Tower Institute, Vol. 10, No. 2, 1989, pp. 26-34.
- Matson, J. V., "The Concern over Minifund Hazardous Waste Sites," The Environmental Forum, Vol. 4, No. 11, March, 1986.
- Matson, J. V., "Sidestream Softening at USS Chemicals," Oil and Gas Journal, May 20, 1985, pp. 76-78.
- Spear, K. F., and J. V. Matson, "Cooling Water Reuse with Sidestream Softening," Power, Vol. 128, No. 12, December, 1984.
- Matson, J. V., "Energy Conservation through Cooling Water Treatment," Energy Progress, Vol. 3, No. 3, 1983, pp. 182-185.
- Matson, J. V., "Reduction in Chlorine Requirements by Control of Nitrification in an Oxygen Activated Sludge Process," Water Research, Vol. 16, 1982
- McGaughey, L. M., and J. V. Matson, "Prediction of the Calcium Carbonate Saturation pH in Cooling Water," Water Research, Vol. 14, November, 1980, pp. 1729-1735.
- Matson, J. V., Clifford, D. A., and Mouche, R. J., "Advances in the Treatment of Cooling Tower Blowdown," ASME, 80-IPC/Pwr-6, 1980
- Matson, J. V., "Zero Discharge of Cooling Water by Sidestream Softening," Journal of the Water Pollution Control Federation, Vol. 51, No. 11, 1979, pp. 2602-2614.

- Matson, J. V., "Design Concepts of the New City of Houston 69th Street Advanced Waste Treatment Plant," Progress in Water Technology, Vol. 8, 1977.
- Matson, J. V., "Treatment of Cooling Tower Blowdown," Journal of the Environmental Engineering Division, ASCE, February, 1977.
- Matson, J. V. and Coneway, C. R., "Economics of Disinfection," Forum on Ozone Disinfection, International Ozone Institute, 1977.
- Matson, J. V., "AWT at Woodlands, Texas," Water and Wastes Engineering, December, 1976.
- Matson, J. V. and Characklis, W. G., "Diffusion into Microbial Aggregates," Water Research, Vol. 10, 1976
- Kessick, M. A., Pipes, D. M., and Matson, J. V., "A Simple Drift Measurement Technique for Industrial Cooling Towers," Environmental Letters, Vol. 8, 1975
- Kessick, M. A, and Matson, J. V., "Co-distillation of Boric Acid with Water under Ambient Conditions," Tellus, 1975.
- Matson, J. V., and Characklis, W. G. "Diffusion of Oxygen through Microbial Aggregates," Water AICHE Symposium Series, 1974., vol.71.
- Matson, J. V., et al., "Mathematical Model of Biological Reactor Design Incorporating Characteristics of Cell Aggregates," Water AICHE Symposium Series, 1973, Vol. 70.
- Matson, J. V., and Bennett, G. T., "Cost of Industrial and Municipal Waste Treatment in the Maumee River Basin," ASME, 69-PID-4, 1970

Conference Proceedings

- Camarda, C., S. Bilén, O.de Weck, J. Yen, and J. Matson, "Innovative conceptual engineering design – A template to teach innovative problem solving of complex multidisciplinary design problems," 2010 ASEE Annual Conference, Louisville, Kentucky, 20–23 June 2010.
- Matson, J.V, and E.A. Goreham, "Zero Emissions Discharge, the Ultimate Solution to Sustainable Industrial Development," Proceedings of the Woodlands-DeLange Conference, Rice University, Houston, Texas, March, 1997.
- Matson, J.V., et. al., "Zero Discharge Technology: A Case Study," Proceedings of the EPA Region 3 Pollution Prevention Conference, Philadelphia, Pa. June, 1996.
- Matson, J.V., and Lamancusa, J.S. "Stimulating Change in Engineering Education Through the Leonhard Center at Penn State University" Proceedings of the Annual ASEE Conference, University of Illinois, June, 1993.
- Thomas, K.B., and J.V. Matson, "Maximum Removal of Heavy Metals from the Wastewater of a Proposed Copper Processing Plant," Proceedings of the 47th Annual Purdue Waste Conference, W. Lafayette, Ind., May, 1992.
- Matson, J.V., "Teaching the Creative Process in the Engineering Classroom," 1987 ASEE Annual Conference Proceedings, June, 1987.

- Matson, J. V. et al., "Energy (Cost) Savings by Zero Discharge in Cooling Towers," Proceedings of the Fourth Annual Industrial Energy Conservation Technology Conference, April 1982.
- Matson, J. V., et al., Oxygen Supply Limitations in Full Scale Biological Treatment Systems, Proceedings of the 27th Industrial Waste Conference, May, 1972.

PRESENTATIONS

- Matson, J.V., et al., “PCB Contamination of Rivers and Creeks in the United States.” The 6th International PCB Workshop: Persistent Pollutants Require Persistent Solutions. Visby, Sweden, May, 2010.
- Matson, J.V., et al., “An Investigation into Historical PCB Emissions from Monsanto Corporation in Anniston, Alabama (USA).” The 2nd International PCB Workshop: Recent Advances in the Environmental Toxicology and Health Effects of PCBs, Brno, Czech Republic, May, 2002.

Dr. Jack V. Matson
Four Year Case History
April, 2019

1. The City of Crystal Springs v. BorgWarner, Inc., et al. Civil Action No. 2012-0251. Circuit Court of Copiah County, Mississippi. Farrest Taylor. August 2014. P

2. Citgo Petroleum Corporation v. Certain Underwriters at Lloyd's London and London Market Companies. Case No. 2005-1523 14th Judicial District Court for the Parish of Calcasieu, Louisiana. Matt Anderson. August 2014. D

3. General Casualty Company of Wisconsin, et al., v. Robin, Inc., and Ray Gehrig, v. Century Indemnity Company. Case No. 12-CV-1381. Circuit Court Rock County, Wisconsin. Jeff Evans. August 2016. P & 3rd party D

4. Town of Westport, et al., v. Monsanto Company, et al., Civil Action No. 1:114-CV-12041-DJC. U.S. District Court, District of Massachusetts. Brett Land. September 2016. P

5. Hexcel Corporation vs. Allianz Underwriters Insurance Company, formerly known as Allianz Underwriters, Inc.; et al., No. ESX-L-7918-12. Michael Hrinewski. June 2017. D

6. City of Hartford, et al., v. Monsanto Company, et al., Case No. 3:15-cv-01544 (RNC). Brett Land. September 2017. P

Notes:

D on behalf of Defendants
P on behalf of Plaintiffs
Trial testimony where stated

APPENDIX B

Plasticizer Properties, Function and Performance Studies

PLASTICIZERS PROPERTIES, FUNCTION AND PERFORMANCE STUDIES

Plasticizers are chemicals added to polymers such as rubbers and resins to impart flexibility, workability or stretchability (Merriam-Webster, 2016). The simplest definition of a polymer is a chemical made of many repeating units, which can be formed into a wide variety of products at various thicknesses. Sealants are an example of a polymer used to seal joints or openings against the intrusion or passage of any foreign substance such as water, gases, air, or dirt[1]. The performance of a plasticizer is evaluated based on the performance and properties of the plasticizer-polymer combination (Craver, 1948; Doolittle, 1954; Emerson et al, 1950)[2]. Three important properties considered when evaluating plasticizer-polymer suitability are compatibility, efficiency, and permanence (Boyer, 1951). Compatibility refers to the maximum amount of plasticizer that can be added to a polymer without noticeable separation of the compound upon standing. Efficiency is a measure of how much a given amount of plasticizer alters a desired property of the polymer, e.g. brittle point, hardness, stiffness, etc. Permanence refers to how well a plasticizer is retained in the polymer matrix under specified aging conditions and is generally dependent on volatility, extraction resistance, migratory behavior, and heat and light stability (Craver, 1948; Mellan, 1961).

Plasticizer toxicity was also identified as a property for both the processor and the user of the final product to consider when formulating a product for commercial use (Reed, 1947; Mellan, 1961; Golding, 1959). However, the compositions of many plasticizers such as Aroclors were not commonly known because manufacturers of the plasticizers did not divulge this information or because the methods of production did not yield products that were pure compounds (Doolittle, 1954). Therefore, it was important for the manufacturer of the plasticizer to communicate important properties (such as vapor pressure and toxicity) of the material to the compounders of the polymer products. Similarly, the end user usually did not know the individual components of a polymer product. In the book *Construction Sealants and Adhesives* (1970), the author commented, “the consumer has no way of knowing the ingredients of any particular sealant.”

Research on plasticizer behavior in polymer compositions has shown that plasticizers are not permanently bonded to, or encapsulated in, the final polymer products. Plasticizers were known to migrate via diffusion from the polymer compound and into adjacent materials, such as supporting structures (masonry, brick) or lacquers, varnishes, and resins (Mellan, 1961). During the lifetime of a plasticized polymer, losses occur when the plasticizer molecules diffuse from the interior of the polymer to the surface, and undergo volatilization. The plasticizer will volatilize or migrate into the adjacent media with which it is in contact, e.g. air, liquids or solids (Reed, 1947; Small, 1947; Mellan, 1961; Sundahl, et al, 1999; USEPA, 2010; Guo et al, 2012). Plasticizer losses to liquid (e.g. water) occur when the small liquid molecules penetrate the plasticizer-polymer matrix and dissolve the

[1] Reference books on construction materials and plasticizers use overlapping terminology when referring to sealant, caulk, mastic and glazing. For simplicity, the term sealant in this section represents all of these materials.

[2] In 1947, Mr. J. Kenneth Craver, Monsanto’s Plasticizer and Resin Coordinator presented on “The Mechanism of Plasticization in Plastics” at the Symposium on Plastics at a meeting of the ASTM Committee D-20 on Plastics. The presentation was reproduced in the ASTM Bulletin. Emerson et al (1950) is a publication written by four Monsanto employees. The publication discussed compatibility testing of plasticizers for polyvinyl chloride (PVC) polymers.

plasticizer into the liquid, which is then excreted from the surface of the polymer into the liquid medium (Stark et al, 1982).

Plasticizer losses from the polymer are evaluated in different compounds using permanence or accelerated aging testing. Manufacturers and users of polymer compounds are concerned with the plasticizer loss rate from the standpoint of how well the polymer product performs under the typical use conditions and for how long it will perform. The loss rate tests, however, do not evaluate air concentrations in a room in which the plasticizer has escaped.

Plasticizer permanence was studied by industry experts (including Monsanto) to evaluate the performance of polymer products in various applications. Although the specific rate of plasticizer loss depended on specific compositions and conditions, these studies provided useful generalizations regarding plasticizer behavior. Research has shown that during the lifetime of a plasticized polymer, the plasticizer is lost through contact with air, liquids or adjacent solids. The rate of plasticizer loss through volatilization is a function of the molecular weight and vapor pressure of the plasticizer. The volatilization losses were determined not only by the properties of the plasticizer alone, but by the plasticizer polymer combination and the thickness of the finished product (Reed, 1943; Craver, 1948; Boyer, 1949; Emerson et al, 1950; Doolittle, 1954; MONS 080627, 1961; Mellan, 1961; American Chemical Society, 1965).

Research has also shown that plasticizer loss is a function of both the diffusion rate through the polymer to the surface and the diffusion rate from the surface into the environment, *i.e.* air (volatilization), water or adjacent solids. The loss mechanism depends on both the compound composition and the conditions of exposure. The studies cited in this report have demonstrated that plasticizers volatilize from polymers, regardless of whether the polymer is a thin coating like paint or a thicker material like a joint sealant.

Monsanto published an article in 1931 discussing the compatibility of PCBs with nitrocellulose lacquers (a type of coating). The article described the experiments conducted to evaluate compatibility and permanence of Aroclors in the lacquers. Monsanto described the volatility test used in its experiments. The results showed that Aroclors 1242, 1254, and 1262 volatilized from the lacquer from the start of the test, with decreasing vaporization rates as the percentage of chlorines increased. In other words, Aroclor 1242 was more volatile than Aroclors 1254, which was more volatile than Aroclor 1260. The article described the Aroclors as "very stable chemically" in that they were not subject to hydrolysis under ordinary conditions and were resistant to oxidation (Jenkins et al, 1931). These characteristics explain why Aroclors, once they migrate from the polymer product, do not readily breakdown, such that they can persist in the natural environment.

When Small (1947) studied the loss of plasticizers from resin sheets, plasticizer volatilization began immediately, practically independent of the sheet thickness, and the percent loss over time increased with increasing temperature. Small (1947) also found that the relationship between amount of plasticizer lost and time was linear until 20% to 30% of the plasticizer was lost. The author concluded that elevated temperatures could be used for accelerated permanence testing as

long as the mechanism of loss was the same under accelerated and normal use conditions. Mellan (1961) provided a literature review of a number of studies evaluating plasticizer volatilization from polymers. The author described a study by Reed and Conner of Bakelite Corporation in which the researchers had evaluated the performance of ninety nine different plasticizers (including Aroclors). Their research showed that although the rate of plasticizer loss in resin sheets of varying thickness at constant temperature varied based on the plasticizer utilized, in general the loss rate remained constant after the first day up to the time when 50% of the plasticizer had escaped. These studies showed that the rate of plasticizer volatized per day was independent of sample thickness up until 20 to 50% of the plasticizer in the sample had escaped. The rate of plasticizer loss in the thinner films would decrease at that point, but the thicker samples would maintain the same loss rate for a longer period of time. (Mellan, 1961).

One of the tests performed by Monsanto to evaluate the performance of Aroclor plasticizers in various polymer compounds was a “Volatility” test, which measured the percent of plasticizer lost from the compound after heating to 86°C for 24 hours (DSW 352447, 12/1960). Although this was an accelerated test conducted at a temperature above the conditions for which the polymer was intended, Monsanto used this test to compare the performance of its plasticizers, including Aroclor 1254, to a competitive product in polysulfide sealants (TOWOLDMON0053111, 8/12/1971).

In another experiment performed by Monsanto’s chemist, metallic surfaces were coated with paint mixtures containing Aroclor 1254 and then submerged in water. After two weeks, detectable amounts of PCBs had accumulated in the surrounding water. This test indicated that PCBs could be extracted from coatings by water (MONS 068229, 3/1970).

Thiokol Chemical Company (Thiokol) had a certification specification that included a 180°F weight loss test to verify “aging stability” and “lack of excessive volatiles”[3]. In an effort to establish reasonable limits for the Thiokol Building Trades Performance Specification (issued 6/1/1965), Thiokol had studied weight loss of over 80 sealants exposed to natural conditions and compared the results to heat aging tests (Boller, 1976; Peterson et al, 1976). Also specific to sealant compounds, federal specifications included a test for weight loss after heat aging at 180°F for 14 days (Fed. Spec. TT-S-230a, 5/5/1967). These weight loss specifications were used to evaluate how much plasticizer was lost to ensure that the polymer product would perform under the typical use conditions.

[3] Thiokol held the basic patents to a liquid polysulfide polymer (Thiokol LP) and was the primary supplier of Thiokol LP to the polysulfide sealants formulators in the United States. Monsanto authored a technical bulletin titled, “Monsanto Modifiers for Thiokol® polysulfide liquid polymers” with Thiokol’s cooperation in its preparation.

APPENDIX C

PCBs in Stormwater – Source Examples and Transport Mechanisms

PCBS IN STORMWATER – SOURCE EXAMPLES AND TRANSPORT MECHANISMS

Research has shown that legacy PCB contamination sources and transport mechanisms are similar in developed regions throughout the world. In the 1970s researchers reported that atmospheric transport of PCBs via volatilization and windblown dust were major pathways for PCBs in the global environment. Volatilized PCBs attach to dust and soil particles and as the dust or soil circulates in the air, PCB-contaminated particles are deposited onto the land or into water by deposition or rain-out. Some amount of the PCBs re-volatilizes into the air, reattaches to particles and resettles in the environment. This continuous cycling coupled with the persistence of PCBs results in a long-term reservoir and increases potential human and wildlife exposure to PCBs in the environment. (Nisbet et al., 1972; Mackay et al., 1973; Versar, 1976; Eisenreich et al., 1979; Curry, 1976; Shen et al., 1980; Nottoli et al., 1990.)

Other studies from the 1980s through today have documented the continued release of legacy PCBs into the environment. These studies have confirmed that PCBs continue to contaminate stormwater and marine environments many years after Monsanto's sales of PCBs were discontinued. Prior to 1978, PCB-containing items had been dumped "in municipal landfills or at uncontrolled chemical waste disposal sites." (Lewis et al., 1985). The potential release of PCBs from different landfills was studied and it was found that "fugitive emissions of PCBs into the atmosphere can occur at uncontrolled landfills." Elevated PCB concentrations were also detected in air downwind of the landfills, even after exposed capacitors and contaminated surface soil had been removed (Lewis et al., 1985).

Open uses of PCBs for a variety of applications including caulks, paints, and plasters used in building construction continued to be identified as current sources of PCB contamination in the environment. For example, a 1999 publication reported that PCBs were found in soil close to a building constructed with exterior PCB-containing sealant. The pattern of PCB congeners found in the soil and in the remaining sealant were similar, which indicated that the sealant was most likely the source of PCBs in the soil. The authors stated that during remediation of the sealant, higher levels of PCBs could be released into the workplace air from "dust and gases produced during cutting and grinding". The authors also stated that "[i]t is most likely that PCB from sealants have already spread to refuse dumps for used building materials, due to a previous lack of knowledge about the problem." (Sundahl et al., 1999). Similarly, another study showed that pressure washing the façade of a house where PCB-containing sealants were being removed generated small particles containing PCBs. This PCB contaminated wash water then entered the combined sewer system (Åstebro et al., 2000). PCBs had also been used in plaster on building facades in Norway. "The soil samples tend to have a higher concentration than the corresponding plaster from the adjacent wall, which probably has its cause in the high soil organic matter contents that retains PCB." Other building materials that contained PCBs included joint sealing compound, double pane window glazing, concrete, paint and plaster (Andersson et al 2004). Several other studies over the years have shown that PCB-containing sealants have led to environmental contamination. (Harrad et al., 1994; Priha et al., 2005; Herrick et al., 2007; Diamond et al, 2007; Robson, 2010; Klosterhaus et al., 2014)

Large surfaces painted with PCB containing paint were a concern for soil, water and air contamination, especially "in areas burdened with a wet coastal climate facilitating continuous weathering of surface materials." (Jartun et al., 2009) "Chips of paint may easily scour off from surfaces during heavy rainfall and wind, and, subsequently, impervious surfaces will facilitate a particle-bound dispersion through the

urban environment via the stormwater sewage system. It may consequently be a significant source of marine sediment contamination. High concentrations of PCB_7 found in stormwater sediments indicated an active and ongoing dispersion of PCBs from the contaminated surface to the stormwater system." (Jartun et al., 2009).

In the early 1990s, PCBs were found in polysulfide caulk used to seal joints between concrete floor panels at a drinking water reservoir in California. Management was initially unaware of the PCBs in the caulking material and environmental contamination of the local area from reservoir sediments was discovered. The affected areas required remediation and restoration and the water authority inventoried at least 84 other reservoirs that could potentially also be impacted (Sykes and Coate, 1995).

Researchers have found that "atmospherically derived organic films accumulate on urban impervious surfaces. The films develop due to the condensation and deposition of gas- and particle- phase organic compounds and their transformation products that occur at elevated concentrations in urban air." (Gingrich et al., 2001). These films retain and accumulate PCBs that partition into the film from the air or are attached to particles that are captured on "greasy" surfaces (e.g. surface films on windows of urban buildings). These PCBs can then volatilize back into the air and/or be washed into stormwater. The congener patterns found in surface films in urban and suburban locations were more similar to those in Aroclor mixtures than those at rural locations indicating that the urban film was from a more recent "fresher" source. "Fresh" sources are likely "electrical equipment, industrial sources, volatilization from past PCB spills, disposal or storage sites, and incineration of PCB-containing materials," as well as buildings constructed in the 1950s to the mid-1970s when PCBs were used in building materials, as well as in transformers and capacitors until these uses were banned, but the materials were not removed. The films at rural locations "had profiles that were shifted to lighter homologues." These "aged" patterns were "a result of preferential volatilization of lighter congeners . . . and more rapid removal of heavier congeners by atmospheric deposition. . ." indicative of atmospheric transport originating from an urban source (Gingrich et al., 2001). These results are in agreement with what researchers had reported in the 1970s literature. (Nisbet et al., 1972; Mackay et al., 1973; US EPA, 1976; Eisenreich et al., 1979; Curry, 1976; Shen et al., 1980; Nottoli et al., 1990).

Miller et al. (2001) showed that air from Chicago contained PCBs that then deposited over Lake Michigan. The authors stated "it is clear that urban/industrial areas are large sources of atmospheric PCBs." They concluded that "[r]eduction strategies should focus on the identification of major volatilization sources in the Chicago region and elsewhere that PCBs have historically been used. . . Reduction of this potentially large source of PCBs to the lake may focus on construction and demolition at PCB contaminated sites and other activities that suspend particles in the urban/industrial areas around the lake." (Miller et al., 2001). In another study of Chicago air, sources of the PCBs found in the atmosphere were linked to sludge drying beds, a large landfill, and a transformer storage yard. The study suggested that the PCBs attributed to the landfill emissions may have been increased from use of wastewater treatment plant (WWTP) sludge as cover (Hsu et al., 2003).

A study of stormwater in Switzerland revealed that "a major part of the PCB load in the environment or in WWTP sludges originates from urban stormwater." The "PCB fingerprint in [the] urban stormwater [from this study was] identical to a commercial mixture of PCBs [ie. Aroclor 1242 + 1254 + 1260]." (Rossi et al., 2004). When stormwater was handled in combined systems with wastewater, the PCBs were mainly trapped in the WWTP sludge and their fate was then dependent on sludge handling. Separate

storm sewer systems were common practice to avoid wastewater dilution and volume overload (and improve treatment efficiency) in WWTPs. "In [these] case[s], PCBs are introduced into the receiving water and can be a major source of toxic substances in the environment (rivers and lakes)." (Rossi et al., 2004).

Researchers found that storm flow in the tidal Anacostia River in Washington DC contained higher levels of PCBs (up to 80 times more) than base flow. (Hwang and Foster, 2008). In a separate study, sediments along a section of the Potomac River basin (mid-Atlantic USA region) were analyzed for PCB concentration. ". . . [T]he highest PCB concentrations occurred in the urban region and were likely related to urban structures of some type, such as outfalls or storm sewers." (Foster et al 2008) Researchers studying the Ballona Creek watershed which feeds the Santa Monica Bay in California reported that reductions of PCB emissions in this area "can only be achieved through reductions in suspended solids discharge in stormwaters." The authors stated that their results were likely applicable to other urban areas with legacy uses of PCBs (Curren et al., 2011). Another study demonstrated that "stormwater runoff is an important dispersion mechanism of toxic pollutants." The authors stated that the stormwater sediments analyzed in the study may have consisted "of a variety of fragments scoured off impervious surfaces and settled in stormwater traps." They concluded that "there are several active pollution sources [in Norwegian cities] supplying the runoff systems with PCBs" and that "if contamination still occurs via urban stormwater runoff, any remediation [of contaminated marine sediments] will only have a short-term effect." (Jartun et al, 2010)

Unfortunately, legacy PCBs in building products are still a source for future contamination. In looking to remediate and control urban PCB contamination, building products, particularly sealants, are an important source because they are a significant portion of PCBs still in use (10–18%) and also they are open sources that are "continually exposed to the full gamut of potential loss processes, such as volatilization, wash-off and erosion." (Andersson et al., 2004; Kohler et al., 2005; Robson et al 2010). "Removal and appropriate disposal of old joint sealants from construction materials is crucial to prevent significant amounts of PCB being released into the environment and, eventually, into the food chain." (Kohler et al 2005). A model of PCBs developed for Toronto led the authors to conclude that "[t]he reservoir [of PCB stock] is enormous and a loss of only a tiny fraction of the reservoir is sufficient to contribute to maintaining ambient PCB levels." (Diamond et al., 2010). Similarly a different group of researchers concluded that "even decades after their ban, relevant but still not entirely characterized stocks of PCBs exist in industrialized countries such as Switzerland. As long as PCB-containing applications remain in use, these primary sources will sustain elevated environmental levels for decades." (Diefenbacher et al., 2015)

APPENDIX D

Vapor Pressure

VAPOR PRESSURE CALCULATIONS

Southern Research Institute (SRI) provided equations to estimate the vapor pressure of Aroclors 1242, 1248 and 1254 within the temperature range of 25 to 100°C (TOWOLDMON0048965, 2/4/1954). The relationship of temperature and vapor pressure for Aroclor 1254 was given by

$$\log P = -\frac{3{,}780}{T} + 8.62$$

where:
P = the vapor pressure of Aroclor in mmHg
T = the temperature in K

For example, at 100°F (37.8°C) the vapor pressure is 2.87×10^{-4} mmHg. The ideal gas law was used to calculate the saturation concentration of Aroclor 1254 vapor in air be 4.8 mg/m^3 at 100°F. It is in the same range of other values reported for Aroclor 1254 at 100°F as shown in Table 1.

Monsanto's reported vapor pressure in tables given in its 1960 bulletins was 6×10^{-5} mmHg at 100°F. This number is an order of magnitude lower than the values extrapolated from the vapor pressure charts in Monsanto's 1945 technical bulletin (MON-MT—001618, 1945) as well as from the chart given in the 1960 bulletin (DSW352447, 12/1960). The incorrect value from the Monsanto product bulletins of the 1960's was then repeated throughout other technical literature including Material Safety Data Sheets (MSDSs) from 1988 and 1995 and an Environmental Science and Pollution Research article published in 2010 that cites a Monsanto MSDS from 2004 (Erickson et al, 2010).

Table 1. Vapor pressures for Arcolor 1254 from SRI and Monsanto documents.

Source	Temperature	Vapor Pressure (mmHg)	PCB Saturation in Air (mg/m^3)
Monsanto Tables[1]	100°F (37.8C)	6×10^{-5}	1.0
SRI Data (1954)[2]	99.5°F (37.5°C)	2.87×10^{-4} 2.76×10^{-4}	4.8 4.7
SRI Equation/Calc[2]	100°F (37.8°C)	2.9×10^{-4}	4.8
Extrapolation from Monsanto Graph[3]	100°F (37.8°C)	6×10^{-4} (1945) 9.3×10^{-4} (1960)	10.0 15.6

[1] TOWOLDMON0029987, no date; DSW 352447, 12/1960
[2] TOWOLDMON0048965, 2/4/1954
[3] DSW352447, 12/1960; MON-MT-001598, 1945

Figure 1 shows vapor pressures as a function of temperature for Aroclor 1254. The line was drawn based on the equation in SRI's final report to Monsanto (TOWOLDMON0048965, 2/4/1954). The other data points were obtained from a number of sources including Monsanto's bulletin and internal communications, USEPA's estimation, and the American Industrial Hygiene Association guide sheet. The vapor pressure provided in the 1960s Monsanto bulletins was incorrect as compared to other sources.

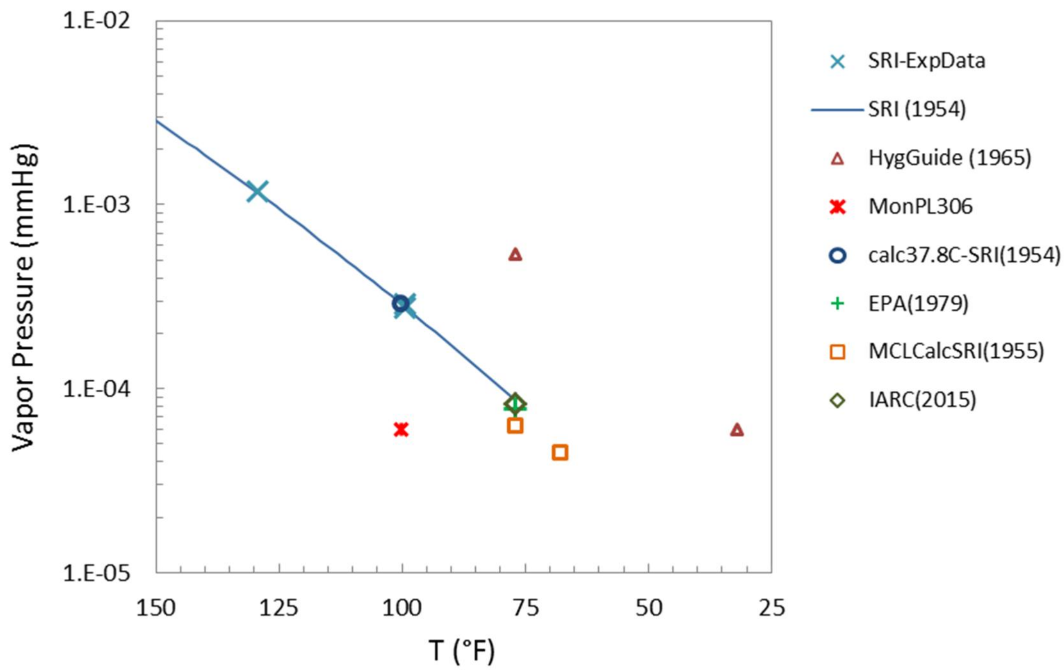


Figure 1. Vapor Pressure (mmHg) as a function of Temperature (°F) over the range 30 to 150°F.

MonPL306 = DSW 352496, 12/1960
SRI-ExpData and SRI (1954) = TOWOLDMON0048965, 2/4/1954
MCLCalcSRI = MONS 095191, 12/6/1955
HygGuide (1965) = MONS 076148, Jan-Feb 1965
EPA (1979) = Callahan et al, 1979

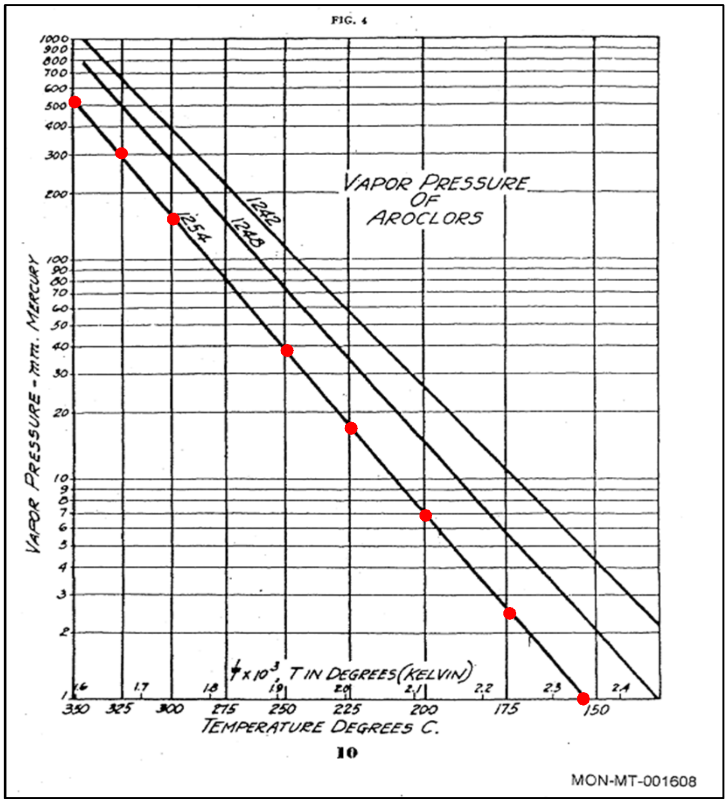
Literature References

Erickson, M. D. and R. G. Kaley II. 2010. "Applications of Polychlorinated Biphenyls." *Environmental Science and Pollution Research* 18 (2): 135–51.

Callahan, M, et al. 1979. "Water-Related Environmental Fate of 129 Priority Pollutants." EPA-440/4-79-029. US EPA.

International Agency for Research on Cancer (IARC). 2015. Polychlorinated Biphenyls and Polybrominated Biphenyls. *IARC Monographs* on the Evaluation of Carcinogenic Risks to Humans v107.

The estimated vapor pressure of Aroclor 1254 at 100 deg F extrapolated from the values shown in Figure 4 (MON-MT-001598, 1945 The Aroclors)

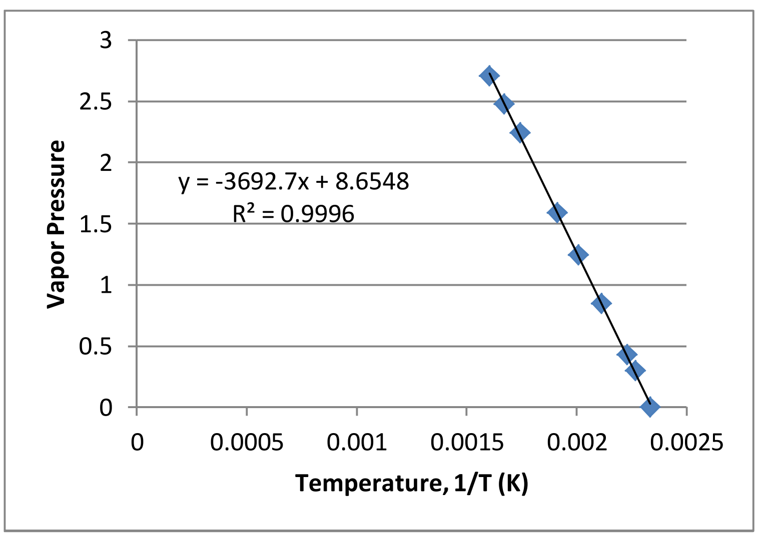


T [C]	1/T [K]	Pv [mmHg]	logP
155	0.002336	1	0
168	0.002267	2	0.30103
175	0.002231	2.7	0.43136376
200	0.002113	7	0.84509804
225	0.002007	17.5	1.24303805
250	0.001911	39	1.59106461
300	0.001745	175	2.24303805
325	0.001672	300	2.47712125
350	0.001605	510	2.70757018

Calculate vapor pressure at 100 deg F

$y = -3692.7x + 8.6548$

T [C]	1/T [K]	logP	Pv [mmHg]
37.8	0.003216	-3.22074	6.02E-04



The estimated vapor pressure of Aroclor 1254 at 100 deg F extrapolated from the values shown in Figure 3 (DSW 352447, 1960 Aroclor Plasticizers Technical Bulletin No. PL 306)

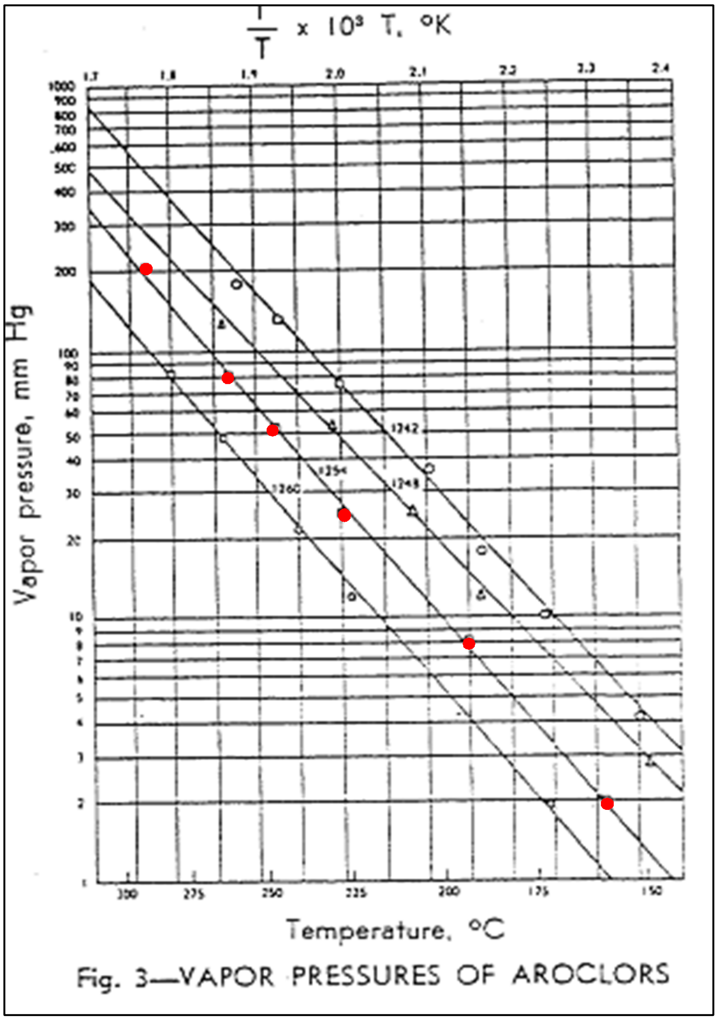


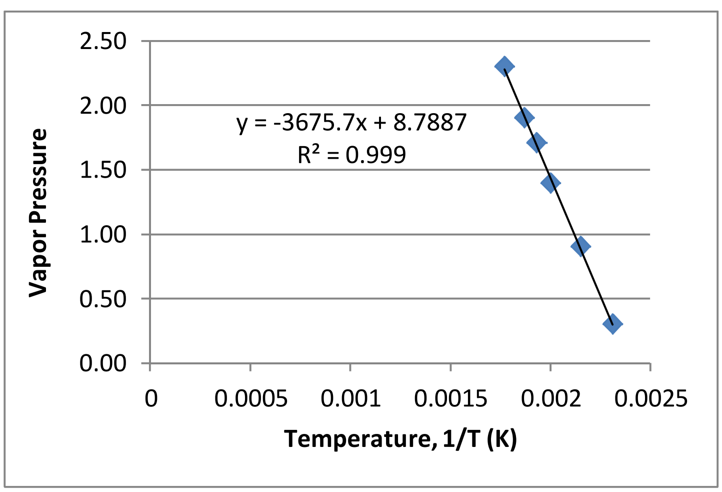
Fig. 3—VAPOR PRESSURES OF AROCLORS

1/T * 10^3[K]	1/T [K]	Pv [mmHg]	logP
2.31	0.00231	2	0.3010
2.15	0.00215	8	0.9031
2	0.002	25	1.3979
1.93	0.00193	51	1.7076
1.87	0.00187	80	1.9031
1.77	0.00177	200	2.3010

Calculate vapor pressure at 100 deg F

$y = -3675.7x + 8.7887$

T [C]	1/T [K]	logP	Pv [mmHg]
37.8	0.003216	-3.03217	9.29E-04



APPENDIX E

List of documents

Discovery Documents

PCB-ARCH0126088

17447

20171030102158000

0057996-0058000

005867-005869

0509197-0509207

0627503-0627521

APIFOX00013515- APIFOX00013518

CGKV-A00004240- CGKV-A00004293

DSW 000353- DSW 000369

DSW 001279- DSW 001552

DSW 002969-DSW 002972

DSW 004225- DSW 004226

DSW 006369-DSW 006372

DSW 006849-DSW 006854

DSW 010011- DSW 010203

DSW 010134- DSW 010140

DSW 010148- DSW 010150

DSW 010349

DSW 010712

DSW 011752- DSW 011754

DSW 011799- DSW 011804

DSW 012433- DSW 012445

DSW 013307- DSW 013311

DSW 013504- DSW 013506

DSW 013599- DSW 013607

DSW 013733- DSW 013742

DSW 014256- DSW 014263

DSW 016472

DSW 016524

DSW 016553

DSW 016924

DSW 017243- DSW 017244

DSW 020441- DSW 020443

DSW 034541- DSW 034545

DSW 034658- DSW 034659

DSW 034710

DSW 034839- DSW 034844

DSW 035022- DSW 035039

DSW 035039

DSW 036627- DSW 036629

DSW 074847- DSW 074849

DSW 117325

DSW 117325- DSW 117326

DSW 117655- DSW 117663

DSW 117730- DSW 117732

DSW 117738

DSW 117741

DSW 117818- DSW 117827

DSW 128951- DSW 128952

DSW 147758- DSW 147773

DSW 147911- DSW 147912

DSW 148006- DSW 148007

DSW 148018

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DSW 162366- DSW 162369

DSW 162383- DSW 162404

DSW 164905- DSW 164937

DSW 170845

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DSW 171513- DSW 171515

DSW 173067- DSW 173068

DSW 174433

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DSW 195302- DSW 195305

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DSW 200973- DSW 200974

DSW 201071- DSW 201073

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DSW 282116

DSW 282288- DSW 282300

DSW 288204

DSW 307691

DSW 307692

DSW 315814- DSW 315870

DSW 318088

DSW 318184

DSW 318222.05- DSW 318222.42

DSW 318222.43- DSW 318222.46

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DSW 318244

DSW 318245- DSW 318252

DSW 318253- DSW 318254

DSW 318257- DSW 318258

DSW 336721- DSW 336722

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NCR-FOX-0616228- NCR-FOX-0616232

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NCR-FOX-325163- NCR-FOX-325165

NEV 022156- NEV 022158

NEV 023924

NEV 024083

NEV 027182- NEV 027184

NEV 037862

"Polychlorinated Biphenyls and Polybominated Biphenyls," IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 107, 2016

"Toxicity Considerations in Pollution Control" by Jack T. Garrett 1957

10-20-1948 News Clippings

Chlorodiphenyl (54% chlorine), NIOSH Pocket Guide, http://www.cdc.gov/niosh/npg/npgd0126.html, 2016

Deposition of E. Scott Tucker, III in Abernathy, et al., v. Monsanto Company et al. (1-5-1999)

Deposition of Gerald Miller in Abernathy, et al., v. Monsanto Company et al. (10-29-2001)

Deposition of Robert G. Kaley, II, Ph.D. in Town of Lexington v. Pharmacia Corporation et al.

Deposition of Robert G. Kaley, II, Ph.D. in Town of Lexington v. Pharmacia Corporation et al.

Deposition of Robert G. Kaley, II, Ph.D. in Town of Westport v. Monsanto Company et al. (4.5- 6.2016)

Deposition of Robert G. Kaley, II, Ph.D. in Town of Westport v. Monsanto Company et al. (4.5-6.2016)

Deposition of Robert G. Kaley, II, Ph.D. in Edward Colella v. Monsanto Company et al. (11/17-18//2001) and exhibits

February 21, 1967 letter from Emmet Kelly to Gene Wilde

Letter from L.W. Spelyar from Indiana State Board of Health to Dr. Emmet Kelly, 2.21.1950

Letter from W.L. Matthews (Monsanto) to Martha McInnis (EnviroSouth); November 7,1978

Memo from Emmet Kelly to Paul Hoffman, 3.30.1965 re: Chloracne

NIOSH criteria for a Recommended Standard …. Occupational exposure to Polychlorinated Biphenyls (PCBs), 1977

Reitman Report

The Wisconsin Ban on DDT: Old Law, New Content - William G. Moore

Klosowksi Ex 12

Klosowski Deposition

Klosowski Ex 11

Klosowski Ex 2

Klosowski Ex 9

PHGNCR-2001875- PHGNCR-2001879

PHGNCR-2001875- PHGNCR-2001879 (0000454)

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PCB-ARCH0735111

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2016 Comprehensive Plan

Ecology Presentation Monitoring Toxics in the Spokane River Watershed

EPA's disapproval of Ecology's 170ppq standard (in favor of lower 7ppq standard

MONS051270- 051290

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PCB-ARCH0552045- PCB-ARCH0552228

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PCB-ARCH0250589- PCB-ARCH0250587

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PCB-ARCH0241548- PCB-ARCH0241557

PCB-ARCH-EXT0016668

PCB-ARCH-EXT0016669- PCB-ARCH-EXT0016672

PCB-ARCH-EXT0016689- PCB-ARCH-EXT0016732

PCB-ARCH-EXT0016616- PCB-ARCH-EXT0016630

PCB-ARCH-EXT0016579- PCB-ARCH-EXT0016584

PCB-ARCH0163243- PCB-ARCH0163253

HARTOLDMON0029995- HARTOLDMON0030124

PCB-ARCH0227299

PCB-ARCH-EXT0013623-PCB-ARCH-EXT0013628

PCB-ARCH0444390

PCB-ARCH0280269- PCB-ARCH0280309

PCB-ARCH0060396

PCB-ARCH0030312- PCB-ARCH0030313

PCB-ARCH0296690- PCB-ARCH0296705

PCB-ARCH0685369- PCB-ARCH0685376

PCB-ARCH0062082

PCB-ARCH0080758

PCB-ARCH0497221

PCB-ARCH0270558- PCB-ARCH0270560

PCB-ARCH0102018- PCB-ARCH0102020

PCB-ARCH0147424- PCB-ARCH0147425

PCB-ARCH0070840- PCB-ARCH0070845

PCB-ARCH0579082- PCB-ARCH0579084

PCB-ARCH0033722

PCB-ARCH0577266

PCB-ARCH0290075

PCB-ARCH0076406

PCB-ARCH0060394- PCB-ARCH0060395

PCB-ARCH0250620- PCB-ARCH0250622

DSW011945- DSW011949

HARTOLDMON0028203- HARTOLDMON0028233

HARTOLDMON0000304- HARTOLDMON0000306

HARTOLDMON0000335

HARTOLDMON0000336- HARTOLDMON0000339

HARTOLDMON0000747- HARTOLDMON0000761

HARTOLDMON0000794- HARTOLDMON0000797

HARTOLDMON0004571

HARTOLDMON0004516

HARTOLDMON0000182- HARTOLDMON0000288

HARTOLDMON0004547- HARTOLDMON0004575

MONS057292- MONS057295

MONS065303

MONS071541- MONS071573

MONS078340- MONS078352

MONS089527- MONS089529

MONS089655- MONS089656

MONS089733- MONS089735

MONS089783- MONS089784

MONS089994

MONS090550

PCB-SRCH0000725- PCB-ARCH0000727

PCB-ARCH0000923- PCB-ARCH0000924

PCB-ARCH0078519

PCB-ARCH0238233

PCB-ARCH0299579- PCB-ARCH0299581

PCB-ARCH0392789

PCB-ARCH0517975- PCB-ARCH0517986

PCB-ARCH0530922- PCB-ARCH0530923

PCB-ARCH0633486- PCB-ARCH0633487

WATER_PCB-00036587- WATER_PCB-00036616

TOWOLDMON0022105- TOWOLDMON0022120

TOWOLDMON0023545- TOWOLDMON0023572

TOWOLDMON0027659- TOWOLDMON0027668

TOWOLDMON0035581- TOWOLDMON0035596

TOWOLDMON0039160- TOWOLDMON0039183

WATER_PCB-00005488- WATER_PCB-00005503

WATER_PCB-00006054- WATER_PCB-00006069

Deposition of Robert G. Kaley, Ph.D., February 19, 2019, Volume 1 and exhibits

Deposition of Robert G. Kaley, Ph.D., February 20, 2019, Volume 2 and exhibits

STLCOPCB4044374

0509197- 0509207

MONS098555

HARTOLDMON0000335

PCB-ARCH0024965- PCB-ARCH0024966

TOWOLDMON0014248- TOWOLDMON0014279

WASHARCH00229- WASHARCH00231

MONS037782- MONS037814

MONS057072- MONS057073

PCB-ARCH-EXT0017483- PCB-ARCH-EXT0017484

PCB-ARCH0066747

PCB-ARCH-EXT0021268- PCB-ARCH-EXT0021279

PCB-ARCH-EXT0021243- PCB-ARCH-EXT0021264

PCB-ARCH-EXT0021265

PCB-ARCH-EXT0021266- PCB-ARCH-EXT0021267

MONS006661- MONS006668

CMA085129- CMA085136

CMA067869

DSW333430- DSW333437

WASHARCH00244

WASHARCH00291- WASHARCH00306

DSW117738

NEV037862- NEV037873

DSW117741

PCB-ARCH-EXT0016556- PCB-ARCH-EXT0016574

PCB-ARCH-EXT0016668- PCB-ARCH-EXT0016672

MONS035475- MONS035544

ADA000267- ADA000273

PCB-ARCH0014071- PCB-ARCH0014076

PCB-ARCH0564296

HARTOLDMON0004517

MONS045979

PCB-ARCH0564291

PCB-ARCH0564299